Mind the Gaps!

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MIND THE GAPS!

Legislative means of incentivizing a circular food system through recovery of non-renewable resources from waste

LET OP DE GATEN!

Wetgevende middelen om een circulair voedselsysteem te stimuleren door het terugwinnen van niet-hernieuwbare grondstoffen uit afval

(met een samenvatting in het Nederlands)

OPREZ, RASKORAK!

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Abbreviations

ABPs	Animal by-products
AD	Anaerobic digestion
BAT	Best available techniques
BSF treatment	Black soldier fly treatment
CAP	Common agricultural policy
CE Package	Circular Economy Package
CLP Regulation	Classification, labelling and packaging of substances and mixtures Regulation EC No 1272/2008
CMCs	Component Material Categories
CRMs	Critical raw materials
ECHA	European Chemical Agency
EIA	Environmental Impact Assessment Directive
EoW	End-of-waste
EP	European Parliament
EPR	Extended producer responsibility
ESPP	European Sustainable Phosphorus Platform
EU	European Union
EWR	Early Warning Report
EWSR	European regulation on the shipment of waste
EZK	Ministry of Economic Affairs and Climate Policy (Dutch: Ministerie van Economische Zaken en Klimaat)
FPR	EU fertiliser product regulation
FZOEU	Croatian Fund for Environmental Protection and Energy Efficiency
HAOP	Croatian Agency for the Environment and Nature
HRK	Croatian Kuna (currency prior to the euro)
IED	Directive on Industrial Emissions
JRC	Joint Research Centre
LAP	Dutch National Waste Plan
LNV	Ministry of Agriculture, Nature and Food Quality (Dutch: Ministerie van Landbouw, Natuur en Voedselkwaliteit)
LSGUs	Croatian local self-government units (~Municipalities), Jedinice Lokalne Samouprave (JLS)
MBT	Mechanical Biological Treatment
MINGOR	Ministry of the Economy and Sustainable Development (Croatian: Ministarstvo gospo-darstva i održivog razvoja)
PFCs	Product Function Categories
PGO	Croatian National Waste Management Plan
PHA	Polyhydroxyalkanoate
R&D	Research and development
TRL	Technological Readiness Level
UBMW	Dutch Fertiliser Act (Uitvoeringsregeling Meststoffenwet)
UBP	Unit-based pricing
UWWTD	Urban Waste Water Treatment Directive

Wabo	Dutch General Environmental Law Act (Wet algemene bepalingen omgevingsrecht)
Wbb	Dutch Soil Protection Act (Wet bodembescherming)
Wm	Dutch Environmental Management Act (Wet milieubeheer)
WFD	European Waste Framework Directive
ZGO	Croatian Law on Waste Management

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CHAPTER 1

Introduction

1.1 The Waste Challenge

The rapidly growing world population is expected to soon be drastically outpaced by its own waste generation (by more than double), as a result of excessive consumption habits.[1] In the European Union in 2016, approximately 2.5 billion tonnes of waste were generated,[2] more than 50% of which were not reused or recycled.[3] To bring this down to a personal level, consider that the average European generates 480 kg of municipal waste every year, with only 46% of this waste being recycled or composted.[4] 480 kg is the approximate weight of a racehorse. This may not seem like a lot, but when we consider that the citizen population of the EU is 513 million,[5] and we then consider 513 million horses galloping through European cities, the horse problem becomes huge. Our waste problem is less visible than the hypothetical horses, because once we neatly dispose of our garbage bags, this waste is perceived to have gone 'away' – but it has not gone anywhere. It continues to gallop through Europe, growing with each year and each citizen's 480 kg contribution.

Waste is defined in the European Union (herein: EU) Waste Framework Directive (2008/98/EC) as 'any substance or object which the holder discards or intends or is required to discard'.[6] Each time such a 'substance or object' is discarded, it represents a significant loss of resources (both material and energy) that went into its production, manufacturing, transport and eventual use.[7] Beyond this, there is also the use of resources in the management and disposal process, as well as the potential negative environmental harms in discarding it – namely, the pollution of air, water and soil.[8]

Although construction waste, mining, quarrying and manufacturing waste are the streams that contribute the largest amounts to the total waste generated in the EU each year, significant proportions are also contributed by the solid household waste stream (8.5% of the weight total) and the wastewater stream (10% of the weight total).[9] Taking into account the significant contribution of

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1 Global waste is expected to grow to 3.40 billion tonnes by 2050, more than double the population growth over the same period; S. Kaza, L.C. Yao, P. Bhada-Tata and F. Van Woerden, 'What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050' (World Bank Publication, 20th September 2018), xi.

2 This is a total of all waste streams; Eurostat, 'Waste generation, 2020' (Eurostat Website, 8th January 2020).

3 Eurostat (2020).

4 Commission, 'Commission reviews implementation of EU waste rules, proposes actions to help 14 Member States meet recycling targets' (EC Press Release, 24 September 2018).

5 World Bank, 'Population, total – European Union' (World Bank Data, 2018).

6 European Parliament and Council Directive 2008/98/EC of the 19 November 2008 on waste and repealing certain Directives (Waste Framework Directive) [2008] OJ L312/3, Art. 3(1).

7 Eurostat (2020).

8 Ibid.

9 Ibid.

these two waste streams to total waste generation, maximising their potential for reuse could contribute to minimising the loss of resources from their eventual disposal. Within these two waste streams, organic materials from solid household waste streams (such as vegetable, fruit and garden waste) and 'sludge' from household wastewater in sewage systems are often seen as costly problems despite having a great potential for recovery.[10]

Approximately 60% of urban waste is organic, and the production of sludge has been steadily increasing since the implementation of the European regulation on wastewater treatment.[11] It is estimated that an additional 600 million tonnes of total EU waste could be reused or recycled if the potential of secondary raw materials in waste streams were utilised through recovery.[12] Taking into account especially the variety of potential raw materials that could be recovered from 'VFG' (Vegetable, Fruit and Garden) and 'sludge' waste, the present research has chosen to focus on recovery from these two waste streams.

1.2 The Resource Challenge

It is no secret that the human population does not have a good track record with sustainable use of natural resources. As a result, many of the global environmental problems faced today are rooted in the overexploitation of natural resources – any and all, from fossil fuels and minerals to water, land and biodiversity.[13] Nutrients such as nitrogen, phosphorus, potassium and organic matter are key elements in modern agricultural systems.[14] Nutrients are the molecules which living organisms require for survival and growth, but which animals and plants cannot synthesise themselves. Animals obtain nutrients by consuming food, whereas plants pull nutrients from the soil.[15] Due to their importance for living organisms, nutrients and organic matter are used as fertilisers in our food production,[16] but can also serve different purposes, for example as key ingredients in the production of bio-based plastics.[17]

10 Ellen MacArthur Foundation, 'Urban Biocycles' (OSTARA, 28 March 2017).

11 J. M. Gómez Palacios, et al., 'European policy on biodegradable waste: a management perspective' (2012) Water science and technology 46.10: 311-318: 311-318; Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment (Urban Waste-water Treatment Directive) [1991] OJ L 135/40.

12 Thomas de Romph, 'The legal transition towards a Circular Economy–EU environmental law examined' (Doctoral Thesis, KU Leuven, 2018); Waste Framework Directive, 2.

13 European Environmental Agency, 'Resource efficiency and waste' (EEA Report, 17 June 2019), 2.

14 C.M. Mehta, et al., 'Technologies to recover nutrients from waste streams: a critical review' (2015) Critical Reviews in Environmental Science and Technology 45(4), 385..

15 Lumen Learning, 'Types of Biological Macromolecules' (2020).

16 Marissa de Boer, et al. 'An assessment of the drivers and barriers for the deployment of urban phosphorus recovery technologies: A case study of The Netherlands.' [2018] Sustainability 10.6, 1790.

17 Interview with Herman Walthaus, Policy Coordinator for organic waste and nutrients at the Ministry of Infrastructure and Water management (Den Haag, Netherlands, 23 January 2020).

There are major concerns over the long-term availability of some of these nutrients, particularly those which are non-renewable. For example, phosphorus is sourced from phosphate rock,[18] the biogeochemical cycle of which is balanced in nature.[19] Phosphorus circulates between the Earth's crust and the Earth's surface at a rate of millions of years.[20] However, with human intervention in the cycle through the overuse of phosphorus as a resource, phosphorus increasingly 'flows in a one-way, non-cyclic, direction at a rate three times faster than the natural flow'.[21] The extent of the problem is further confirmed by the fact that we have over-shot six of the nine planetary boundaries, which regulate the stability and resilience of the Earth system – one of which is specifically related to biogeochemical flows.[22]

Through our intervention in the biogeochemical cycles of phosphorus and, such nutrients, we have created a linear extraction system. As such, these nutrients and organic matter are being extracted faster than they can be replenished because we are not effectively reusing the nutrients and organic matter we have already extracted. According to the OECD, overexploitation of resources is particularly problematic not only because of the overexploitation itself, but also because of the negative life cycle impacts of the externalities (climate change, degradation of air, land and wildlife habitats, exhaustion of biomass and topsoil, build-up of heavy metals) associated with resource extraction, transport, utilisation and eventual waste treatment.[23]

1.3 The Recovery Challenge

These overexploitation trends are expected to grow as the world population increases to more than 9 billion people in 2050.[24] If the continuation of these trends is to be slowed or avoided altogether, recovery of secondary raw materials from waste is necessary. According to the EU Waste Framework Directive, *recovery* refers to 'any operation the principal result of which is waste serving a useful purpose by replacing other materials that would otherwise have been used to fulfil a particular function'.[25] To return to the phosphorus example,

18 Mehta (2015) 385.

19 De Boer et. Al. (2018) 1790.

20 Ibid.

21 Ibid.

22 K. Richardson et al. 'Earth beyond six of nine planetary boundaries.' Science Advances 9, no. 37 (2023): eadh2458.

23 Organisation for Economic Cooperation and Development, 'Sustainable Materials Management – Making Better Use of Resources' (OECD Publishing, 2012), 3; The OECD as cited in: de Romph (2018) 4-5.

24 United Nations, 'Growing at a slower pace, world population is expected to reach 9.7 billion in 2050 and could peak at nearly 11 billion around 2100' (UN Website, 17 June 2019).

25 Waste Framework Directive, Art 3(15).

recovery would be the application of operations to waste streams that contain phosphorus to produce a product that can replace the use of virgin phosphorus, sourced directly from phosphate rock, in agriculture and other products.

The challenge of waste and resource is linked for many waste streams. To take the example of food waste, of which VFG is part, we can see that the Sustainable Development Goals of the United Nations, specifically 12.3, call for a halving of per capita global food waste at the retail and consumer levels and a reduction in food losses along production and supply chains by 2030.[26] Reducing food waste has the potential to greatly reduce the resources used in food production. However, the recovery of organic matter from waste would contribute to reducing food losses in production and supply chains along the entire food chain.[27] For example, the Croatian Environmental Agency estimated in 2018 that around 60 million tonnes of bio-waste generated in Europe could be processed by composting and anaerobic digestion procedures.[28] These and other organic resources are currently lost through disposal.

In addition to the environmental harm caused by waste and resource overexploitation, there are a number of public well-being, strategic and financial reasons, which could inspire an increase in the recovery of secondary raw materials from waste. On a global scale, solid waste management affects everyone, but the negative impacts are most immediately felt by the most vulnerable people: those who loose their lives and homes as a result of landslides from waste dumps, those who work in unsafe waste picking conditions and those suffering health repercussions as a result of exposure to waste.[29] However, most of these problems do not take place in Europe directly; because of the nature of global waste management and disposal, much of the developing world is responsible for the management of the developed world's unwanted waste.[30] While that is not the central problem this research aims to resolve, if the recovery processes are fully harnessed, the scale of this problem of public well-being could shrink (because less waste will be landfilled and more will be treated for recovery) – as a preliminary step towards resolving the issue in full.

Recently, the reuse and recovery of resources has gained importance on the global political agenda due to the rising prices of many resources,[31] as well as the fact that several producing countries have restricted the export of particular

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26 United Nations A/RES/70/1 Resolution adopted by the General Assembly on 25 September 2015 [2002], Goal 12.3.

27 Croatian Agency for the Environment and Nature, 'The advancement of reporting systems for bio-waste and food waste [Unaprjeđenje sustava za prikupljanje podataka o biootpadu i otpadu od hrane]' (SAFEGE d.o.o. report, 14 December 2018), p. 23.

28 Croatian Agency for the Environment and Nature (2018) 20; H. Oakdene et. Al., 'Towards a circular economy – Waste management in the EU' (European Parliament Research Service Study, September 2017), 28.

29 Kaza et. al. (2018) 129-132.

30 Ibid.

31 Organisation for Economic Cooperation and Development (2012) 3.

resources.[32] Producing countries such as Russia and those in the Middle East and Northern Africa are increasingly aware that they have the power to 'set the price' for vital resources.[33] As a result, the price of these resources has increased significantly.[34] These financial concerns are increasingly also related to strategic concerns, as the lack of these resources on its own lands makes the EU dependent on producing countries, thus increasing its vulnerability in the supply of commodities that are very important for food security and the agricultural sector.[35]

It is precisely these financial and strategic concerns that have led to the development of new EU legislation on critical raw materials, the list of critical raw materials (herein: CRMs) and the renewed industrial strategy for Europe. These developments are aimed at stimulating the production of CRMs within Europe through new mining activities, but also (more positively) reuse and recycling activities, such as the recovery of valuable materials from waste streams.[36]

Within this context, the aim of reuse and recovery from waste streams is not only to conserve renewable resources in our environment, but also to capture value from these waste streams in the form of resources (nutrients, organic matter and energy).[37] In this way, the circular economy offers us the opportunity to revise our relationship with non-renewable resources we have previously overexploited, in order to close loops and improve conservation. Seeing sludge and VFG waste streams as resources rather than as waste is important in order to unlock the public well-being, environmental, strategic and financial benefits of a circular approach to resource recovery.[38] Before delving into sludge, VFG and material recovery therein, a deeper understanding of the transition to a circular economy is needed.

1.4 The Circular Economy Challenge

The circular economy is an economic model and increasingly also a governance model which aims to eliminate (or drastically reduce) waste through better use of resources.[39] Most of the European Union has moved from a linear economy, active in the 1970s and 1980s, to a recycling economy,

32 The Hague Centre for Strategic Studies, 'Risks and Opportunities in the Global Phosphate Rock Market' (HCSS Website, 2012) 37.

33 Ibid.

34 Ibid.

35 Ibid.

36 European Commission, 'Critical raw materials' (Commission website, May 2020).

37 Ellen MacArthur Foundation (2017).

38 A. Gherghel, C. Teodosiu and S. De Gisi, 'A review on wastewater sludge valorisation and its challenges in the context of circular economy' (2019) Journal of cleaner production, 244.

39 S. Stuebing and Cees Anton de Vries, 'Governance for the Circular Economy' (1st edn, The Netherlands, Origame 2018).

which has been active in the 1990s and largely also in present day.[40] Recycling is at the heart of a recycling-based economy, while a circular economy calls for prevention, re-use and for more advanced reprocessing methods.[41]

The central important distinctions between the two is with respect to input of raw materials and output of residual waste, both of which the circular economy seeks to completely eliminate in an ideal, entirely closed-loop scenario. Furthermore, the circular economy calls for a shift to the use of renewable energy, eliminates the use of toxic chemicals (which impair the possibility of reuse) and aims for the 'elimination of waste through the superior design of materials, products, systems, and, within this, business models'.[42]

In the EU, the circular economy challenge was fully embraced in 2015 with the development of the first *Circular Economy Package* (herein: CE Package), which is 'a set of policy documents and legislative proposals on waste aimed at stimulating the transition towards a circular economy'.[43] One of the central objectives of the CE Package is to build an appropriate regulatory regime which would allow the circular economy to develop.[44] This objective is further supplemented in the EU Green Deal,[45] and particularly the 2021 Circular Economy Action Plan and the Farm to Fork Strategy.[46] These strategies and objectives drive the 'circular economy transition process' which refers to 'systematic

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40 T. Bastein et. Al., 'Opportunities for a circular economy in the Netherlands' (2013) Report of the Netherlands Organisation for Applied Scientific Research; P. de Jong & M. Wolsink, 'The structure of the Dutch waste sector and impediments for waste reduction' (1997) Waste management & research 15(6) 646; Ellen MacArthur Foundation, 'Towards the Circular Economy – Economic and business rationale for an accelerated transition' (2013), 21-23.

41 Ellen MacArthur Foundation (2013), 21.

42 Ibid.

43 De Romph (2018), 3.

44 De Romph (2018) 3.

45 Section 2.1.3, 'A key aim of the new policy framework will be to stimulate the development of lead markets for climate neutral and circular products, in the EU and beyond.'; Section 2.1.6, 'By shifting the focus from compliance to performance, measures such as eco-schemes should reward farmers for improved environmental and climate performance, including managing and storing carbon in the soil and improved nutrient management to improve water quality and reduce emissions'; Section 2.1, 'To achieve these aims, it is essential to increase the value given to protecting and restoring natural ecosystems, to the sustainable use of resources and to improving human health'; Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions, The European Green Deal, COM/2019/640 final, Section 2.1.3 and 2.1.6.

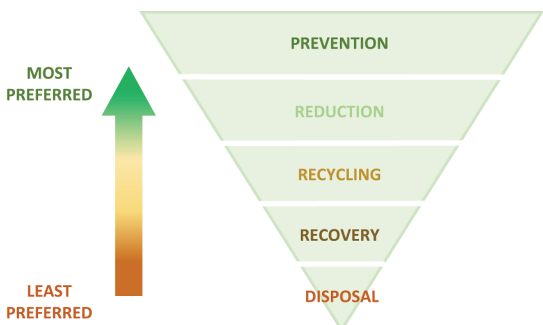
46 Clause 2.3, 'The Commission will take action to scale-up and promote sustainable and socially responsible production methods and circular business models in food processing and retail, including specifically for SMEs, in synergy with the objectives and initiatives put forward under the new CEAP. The deployment of a circular and sustainable EU Bioeconomy provides business opportunities, for instance linked to making use of food waste.' Commission, 'Communication to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, A Farm

movement towards a more circular system'.[47] Generally speaking, we can say this requires the closing of loops in product design, production, use and reprocessing as a way of embracing resource efficiency – as well as through minimizing over-production, over-consumption and wastefulness.[48] These EU circularity objectives are the normative framework against which the legal/policy frameworks and practices at the Member State level will be evaluated in the present research, specifically on the example of VFG and sludge waste streams.

Previous literature on the circular economy, as well as Commission reports on the subject, have already outlined some of the major challenges faced in the transition process.[49] These challenges include a lack of investment in separate collection/recycling infrastructure, a shortage of administrative capacities in Member State governments, limited capacity of existing infrastructure used to treat waste and the illegal transport of waste (resulting in suboptimal, non-environmentally-friendly treatment), just to name a few.

To clarify some of the uncertainties in transitioning to more circular waste management and making the process more operational, the European Union bases its approach to waste management on the waste hierarchy.

Figure 1: The EU's waste hierarchy[50]



to Fork Strategy for a fair, healthy and environmentally-friendly food system', (Communication, May 2020c) COM/2020/381 final, Clause 2.3.

47 Cicerone 'Project Update' (European Union's Horizon 2020 Research and Innovation Program Grant, June 2019).

48 Government of the Netherlands, 'From a Linear to a Circular Economy' (Dutch Government Website, 2017).

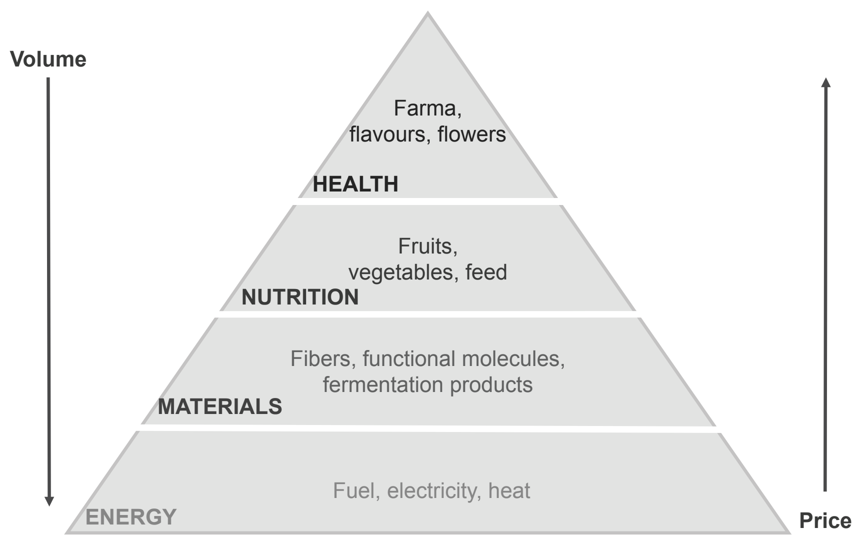
49 De Romph (2018) 48.

50 Thomas Bide and others, 'ORAMA project deliverable 1.2. Final analysis and recommendations for the improvement of statistical data collection methods in Europe for primary raw materials' (2018).

The waste hierarchy, as shown in Figure 1 and as described in the EU Waste Framework Directive, presents the priority order for possible waste management schemes.[51] The Waste Framework Directive combines this priority order with other principles, such as the 'protection principles of precaution and sustainability, technical feasibility and economic viability, protection of resources as well as the overall environmental, human health, economic and social impacts'.[52]

The EU waste hierarchy lines up well with the bio-based value pyramid. The value pyramid, shown in Figure 2, is a concept from the bio-based economy which seeks to encourage the use of the most valuable parts of biomass (such as VFG) to create products with the greatest added value.[53] In a properly functioning market, from the bio-based economy point of view, the value and price of biomass should be reflected in its application value.[54] In a market that functions in that way, the value of a biomass is determined by its applications and end uses.[55]

Figure 2: The Bio-Based Value Pyramid[56]



The easiest way to convert biomass into a product is to combust it and produce energy. While this may be the easiest practise, it is not ecologically desirable or

51 Waste Framework Directive (2018) Art 4.

52 Waste Framework Directive (2018) Art 4.

53 Centre of Biobased Economy, 'The basic principles of a biobased economy' (CBBE Website, 2018).

54 BetaProcess Bioenergy, 'Towards value optimization' (BetaProcess Website, 2020).

55 Ibid.

56 Centre of Biobased Economy (2018).

hugely profitable.[57] As such, it is depicted at the bottom of the pyramid. Other more desirable practices are depicted higher in the pyramid. The value pyramid approach requires optimal value utilisation, meaning that the substances or materials that can be used in high-quality products are isolated first.[58] In the case of VFG, for example, the valuable materials should be reused for nutrition first (in the form of products made from fruits and vegetables for human consumption, or as feed). The remaining components of VFG (nutrients and other organic matter) can be recovered and used as chemicals and materials (e.g. compost). Finally, the remaining VFG biomass can be used to create biogas. This is the lowest-value application in the pyramid.[59]

For both the waste hierarchy and the bio-based pyramid, prevention of waste is the preferred option of handling the streams, followed by reuse, recovery of valuable materials, recovery of energy and, finally, safe disposal.[60] The waste hierarchy and the bio-based pyramid are related concepts and both contribute to the EU strategy to move toward a more competitive, resource-regenerative economic structure.[61]

1.5 The Legislative Challenge

There are several available biotechnological methods for the recovery of organic matter from waste streams, but many of these methods are not applied in the EU on a major commercial scale.[62] Based on preliminary background research and interviews, the present research hypothesised that there are substantial legal barriers to be removed and better legal incentives to be developed which, if applied, could incentivise Member States and private actors to use relevant biotechnological recovery methods more widely.[63] In exploring this hypothesis, the objective was to determine whether the legislative barriers actually exist (and if they exist where and why they are occurring), as well as to determine which legislative and policy tools are needed to overcome identified barriers.

57 Centre of Biobased Economy (2018).

58 Centre of Biobased Economy (2018).

59 Centre of Biobased Economy (2018).

60 European Commission DG Environment, Analysis of the evolution of waste reduction and the scope of waste prevention (2010).

61 I. Russo, Confente, I., Scarpi, D. & Hazen, B. T., 'From trash to treasure: The impact of consumer perception of bio-waste products in closed-loop supply chains' (2019) Journal of Cleaner Production, 218, 967.

62 EIP-AGRI, '100 nutrient recovery technologies and novel fertiliser products' (European Commission Website, 11 November 2019).

63 For other research that uses this barriers/incentives framework see: I.M. de Waal, 'The Legal Transition towards a More Circular Electrical and Electronic Equipment Chain—A Case Study of The Netherlands. ' *Sustainability* 15, no. 2 (2023): 935; C.W. Backes, Law for a circular economy. Eleven Publishing, 2017.

First, it was important to define barriers and incentives.[64] By 'barriers', this research refers to legal and policy obstacles at EU and national levels that are obstacles to the application of circular biotechnological methods in waste recovery. Some of the barriers at the EU level include existing divisions of competences, legal definitions and end-of-waste status, while barriers at the national level include divisions of competence (between central, regional and local authorities), misinterpretation of legislation by national authorities, enforcement and a lack of follow-up on Early Warning Reports from the European Environmental Agency.[65] Other kinds of barriers were also discovered over the course of the research.

By 'incentives', this research refers to types of EU or national legislation that could motivate those public and private actors to go above and beyond the minimum targets. At the EU level, examples of these include the REACH classification, EU certification (such as the Ecolabel), green public procurement and extended producer responsibility.[66] The same types of general incentives can be applied at the national level too, but Member States have the additional advantage of a familiarity with their own economies and can therefore develop topic-specific obligations customised to their national legislative/economic landscape.[67] An example of the latter is a system in France, developed in synthesis with the latest revisions to the EU electronic waste legislation, which pays out fees to extended producer responsibility schemes with the aim of rewarding producers who design electrical and electronic equipment which can be easily dismantled and recycled.[68] These types of semi-governance, semi-economic tools can go a long way in incentivising innovation, which could prove immensely useful for up and coming areas of the circular economy, such as the recovery of organic matter from waste.

This topic can be approached from both a waste legislation perspective and a product legislation perspective. The waste perspective raises a host of issues related to the definition of waste in the EU but also highlights the balancing act between innovation and safety. This perspective is highly relevant for a novel process like recovery of organic matter, which is still mostly in the beginning stages of development for large-scale applications (except for compost). Product

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[64] De Boer et. Al. (2018) 1790; Interview with Herman Walthaus (2020); I.M.K. Saman, et al. 'E-waste in the international context–A review of trade flows, regulations, hazards, waste management strategies and technologies for value recovery'. [2018] Waste management 82, 258; Pigosso (2016) 332; H. Torsteinsen and M. van Genugten, 'Municipal waste management in Norway and the Netherlands: From in-house provision to inter-municipal cooperation' Local public sector reforms in times of crisis (Palgrave Macmillan, London 2018) 205.

[65] De Boer et. al (2018) 1790; Interview with Herman Walthaus (2020); Harald Torsteinsen and Marieke van Genugten (2018) 205.

[66] De Boer et. Al. (2018) 1790.

[67] European Commission, 'Sustainable Products in a Circular Economy – Towards an EU Product Policy Framework contributing to the Circular Economy' (Staff Working Document) SWD(2019) 92 final, 34.

[68] Commission (2019), 35.

and manufacturing law, on the other hand, moves beyond the framework of the circular economy as waste-related. Instead, this legislation is concerned with ensuring that reuse, recycling and re-manufacturing into new *products* is (more) easily possible.[69] In this case, 'products' refers to both recovered materials, but also products which those recovered materials can be turned into in the later stages of production, such as fertiliser or bio-based plastics. This type of wide legislative framework is key for issues such as those of the present research, as both can offer different tools but also pose different barriers to the circular transition at play.

A final element of the legislative challenge is to define who the main actors are. Both private and public actors are involved in the various stages of VFG and sludge material life cycle. The present research defines 'private actors' as collective participants in economic and social life that are not controlled by the state and generally act for profit. It defines 'public actors' as collectives that participate in economic and social life on behalf of a government body, such as a government ministry or agency.

The research approaches the topic from the perspective of public actors and their ability to influence the circularity of nutrients and organic matter, but cannot address this without a portrayal of the role of private actors. This is mainly due to the deeply rooted role of private actors in waste management processes, not to mention the manufacturing and sale of the resulting products. The relationship between these actors is easily evident in the review of waste collection practices by different Dutch municipalities – six of which collect waste themselves, one-third of which have the waste collected by a private company and another third of which set up a public-private waste collection agreement through a limited liability partnership.[70] This simple example is borrowed from only the first stage of waste management (collection), but the subsequent stages entangle the public and private roles even further.[71] This creates a bustling playing field which needs to be mapped out accurately, to ensure the biggest barriers are removed and the most effective incentive measures are implemented.

Furthermore, the dynamics and reciprocity between EU and national actors are also relevant. Environmental and agricultural legislation, relevant legislative topics for the present research, are defined and implemented under the TFEU as shared competences between the EU and its Member States.[72] As such, there are an abundance of issues to be mapped out in this regard: from definitions and interpretation of EU law by Member States, to the shared regulatory space,

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69 This approach of wielding product-oriented legal instruments in support of environmental protection and conservation is also a trend in newer environmental law more widely, going beyond the circular economy; Pigosso et al. (2016), 332.

70 De Jong and Wolsink (1997) 641.

71 Ibid.

72 Consolidated Versions of the Treaty on European Union [TEU] and the Treaty on the Functioning of the European Union [TFEU], Official Journal of the European Union (2008/C 115/01), Art 4.

subsidiarity and extent to which discretion is left to the Member States to go beyond what is called for in EU legislation.

From the perspective of aiming to reach a more circular economy, it is necessary to map all the legislative problems occurring as a result of this complex legislative playing field and have the extracted results inform an evaluation of the barriers to be removed and incentives to be applied to achieve circularity for these resources. In combination, the points of interest lead to the central research question of this dissertation:

'What are the legislative and policy barriers to the application of circular methods in the recovery of organic matter from the household "VFG" and "sludge" waste streams in the Netherlands and Croatia, and what can public and private actors do to overcome them?'

2 Methodology

The remainder of this chapter outlines the study design (selection of Member States, waste streams, guiding research questions), the data collection procedures and the analytic strategy applied over the course of the research. To start, the research is comparative, seeking to compare two EU Member States (the Netherlands and Croatia) in regard to their action and the opportunity for action in the recovery of valuable materials from two bio-waste streams (VFG and sludge). When conducting such comparative research, Oderkerk recommends five phases: a preparatory phase, a descriptive phase, a comparative phase, an explanatory phase and an evaluative phase.[73] The present research is conducted on the basis of this approach. Parallel to this, the research is also structured to follow directly from its initial hypothesis and accompanying objectives, as outlined above in the Introduction.

2.1 Study Design

The research approach brings together various perspectives (legal, governance, biotechnological and practical) in an exploratory approach to address one central issue.[74] As a result, an ambitious methodology had to be balanced with a limited scope. The scope was limited through a focus on two waste streams within two Member States and by looking at a specific number of biotechnological recovery methods of a relatively high level of technological readiness.

[73] M. Oderkerk, 'The Need for a Methodological Framework for Comparative Legal Research-Sense and Nonsense of' Methodological Pluralism' in Comparative Law.' (2015) Rabels Zeitschrift für ausländisches und internationales Privatrecht 79(3), 598.

[74] De Boer et. Al. (2018) 1790.

2.1.1 Selection of Member States

This research has chosen to focus on the Netherlands and Croatia because they can be seen as representatives of two groups in the analysis of Europe through a circular economy lens. From this perspective, the Netherlands represents a recycling economy (with high incineration rates, 46.5%, and relatively low landfilling rates, 1%)[75] striving to become a circular economy. Although Croatia represents a landfilling economy (with non-existent incineration rates and high landfilling rates, 78%),[76], it is on the path to simultaneously becoming a recycling economy and a circular economy. As such, this research is interested in the differences in approach and challenges faced by a recycling economy in the transition to a circular economy (for a country like the Netherlands) and the same for a landfilling economy in the transition to a circular economy (for a country like Croatia).

The present research aims to assess the approach taken by different institutional levels in the two Member States, particularly in parts of the material life cycle where they are relevant (for example, the local level for waste collection). As such, different regions and municipalities were chosen to illustrate this. The explanations for regional and local institutional selection can be found in the corresponding chapters.[77]

2.1.2 Selection of Waste Streams

The relevance of VFG and sludge waste streams is outlined in detail in the Introduction. Although they are not the largest waste streams, household waste and wastewater are significant, coming in at 8.5% and 10%, respectively, of total waste generated in the EU. Organic materials from VFG and sludge from household wastewater are often seen as costly problems despite having a great potential for recovery.[78]

Around 60% of urban waste is organic and sludge production has increased steadily since the implementation of the European regulation on wastewater treatment.[79] It is estimated that an additional 600 million tonnes of total EU waste could be reused or recycled if the potential of secondary raw materials in the waste streams was used through recovery.[80] Taking into account, in particular, the variety of potential raw materials that could be recovered from the 'VFG'

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75 European Parliament 'Waste management in the EU: infographic with facts and figures' (European Parliament Website, 6 April 2018).

76 European Parliament 'Waste management in the EU' (2018).

77 For example, for collection, the justification of selection of local authorities can be found in sections 5.1.1 and 5.1.2 of Chapter 5 on VFG.

78 Ellen MacArthur Foundation, 'Urban Biocycles' (OSTARA, 28 March 2017).

79 Gómez Palacios (2012) 311-318; Urban Waste-water Treatment Directive [1991].

80 De Romph (2018); Waste Framework Directive, 2.

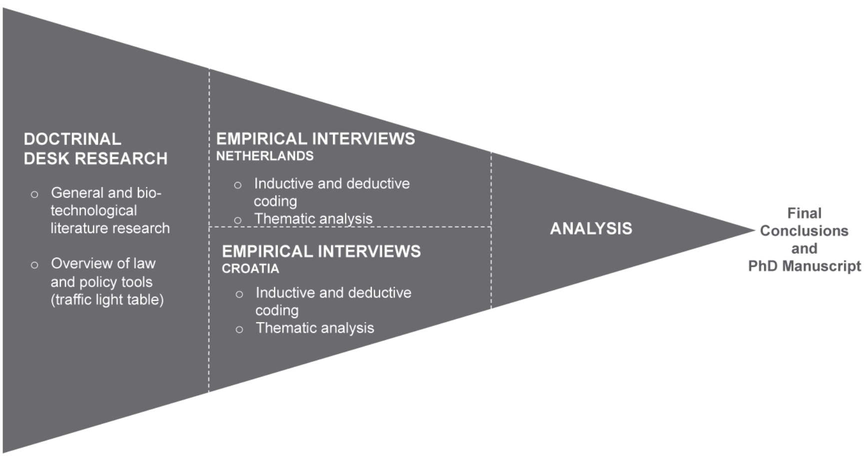
waste (Vegetable, Fruit and Garden) and 'sludge' waste, the present research has chosen to focus on recovery from these two waste streams.

2.1.3 Guiding Sub-Questions

The present research is guided by the following sub-questions:
- What barriers, particularly legislative, exist in the application of circular methods in the recovery of organic matter from 'sludge' and 'VFG' waste streams in the Netherlands and Croatia?
- Where and why do barriers occur?
- What legislative and policy tools can public and private actors use to overcome these barriers?

All three questions are answered through a combined analysis of the results of the legal-doctrinal and empirical data. The combined results lead to an answer to the central research question, as shown below.

Figure 3: Visual representation of the research design



2.2 Data Collection Procedures

The varied methods used to collect the data for the doctrinal and empirical segments of the research are explained herein.

2.2.1 Doctrinal Data Collection

The doctrinal desk research is split into two parts: the general/biotechnological and the legislative. The general part describes the current approach in the EU and the two Member States to organic matter recovery from

VFG and sludge: the quantities of waste collected, the quantities that go on to different treatment and disposal methods (landfill, incineration, recovery, etc) and the main actors involved. The biotechnological part describes the biotechnological recovery methods that are currently most widely applied in the EU and the two Member States, as well as those that have the highest potential to be widely applied. Each method is briefly explained (relevant to the waste streams) and in relation to its place in the relevant circularity loop (i.e. does it come after energy recovery, does it respect the waste hierarchy, etc). The information for the general and biotechnological part was gathered from a literature review of biotechnological research papers and a review of the EU, national and municipal policy documents.

Meanwhile, the legislative part describes the current legislative approach at the EU level and at the Member State level (per waste stream), as well as how competence is shared between these institutional levels in the relevant legal areas. To understand this, information was gathered from scientific literature, legislation and policy documents relevant to virgin materials, waste, creation of products from recovered materials and the circular economy.

Where necessary, the legislative part also looked at legislation and policy at the municipal level. For example, this was necessary when it came to VFG collection and treatment, where many of the decisions regarding these materials are made by municipal bodies. This research was 'closed' on the 1st of July 2023 when it was submitted to the supervising team for review, meaning that it does not cover any legislation, policy or literature that came out after this date.

2.2.2 Empirical Data Collection

The empirical segment sought to explore the experiences of different relevant actors in bringing about a wider commercialisation of available biotechnological recovery methods and the resulting recovered materials. In addition, it compared the degree to which challenges and solutions identified in the doctrinal research were (or could be) reflected in practise. To collect data for this analysis, 25 semi-structured interviews were conducted.

Since the population of interest in this research was public and private actors in the Netherlands and Croatia, whose work touches on the circular use of VFG and sludge waste streams, 25 categories of participants were established. The 25 categories were relevant to each waste stream, each phase of the material life cycle, both Member States and necessary institutional levels. An expert was selected for each of the categories given. The 25 categories, along with the chosen institution or company are shown in Annex I. Exact company names were not given (but rather a description of the role in VFG and the life cycle of the sludge material life cycle) because often the companies (or teams within companies working on this topic) were quite small, which means that the interviewed individuals could easily be identified and confidentiality would not be respected. The condition of confidentiality (wherein the researcher knows the identity of a research subject, but the identity is not divulged to others) was chosen because several of the research subjects preferred to give their opinions on the interview questions in confidence. To avoid inconsistency among the research participants, all subjects were kept confidential, as their identity does not need to be presented to enable their expertise and observations to add value in answering the research questions.

Biased and interest driven answers can occur in any interview setting. To counteract these in the present research several steps were taken. Firstly, a wide range of relevant actors were interviewed. When discussing municipal matters questions were brought to both the municipality and the waste service provider. When discussing a particular phase of the material lifecycle (such as collection or treatment) both a public and a private actor in the sector were interviewed. In this way any biased or interest driven views could be challenged in the final analysis through a comparison of answers between the different actors. Researcher influence on the bias of participants was counteracted by avoiding leading questions during the interviews. A check of this was done in the immediate aftermath of the interviews when the notes or audio from an interview were transcribed and analysed. The interview data was also coded in more than one way to counteract any confirmation bias or anchoring effect (described below in the section titled 'Empirical Analytic Strategy).[81] Furthermore, the data and analysis was discussed with the supervision team at every stage of the process to lend a critical eye to both the initial findings and the ensuing analysis. Finally, findings from the empirical component of the research were checked against and combined with the findings from the doctrinal component of this research, which was based on external sources of data like legislation, policy documents and academic research.

It is evident from the number of interviews conducted that the intention was not for these experts (or their categories) to be representative of an entire population. Instead, the intent was to sample a broad range of experiences relevant to the central topic and to explore the different perspectives on the broad challenges and opportunities in this part of the circular economy transition. To fulfil this intention, a public and private actor relevant to each phase of VFG and sludge life cycle was chosen, for each institutional level (EU, national and, where necessary, also local).

Semi-structured interviews (with previously formulated questions that can be adapted and modified during the course of the interview) were used.[82] Having fixed questions would have stifled the exploratory nature of the research by not allowing a deeper look into the varied experiences of the experts interviewed via follow-up questions and digression from the semi-structured outline of the interview.

81 P.E. Lehner et. Al., 'Confirmation bias in complex analyses.' IEEE Transactions on Systems, Man, and Cybernetics-Part A: Systems and Humans 38, no. 3 (2008): 584-592.

82 L. Ansems, 'Qualitative Interviews' (11 April 2022, Leiden University Website).

On the other hand, having an entirely unstructured format (where only the topic and the initial research question are fixed) would have caused difficulty in comparing the research results because all the interviews would have been too different, with each interviewee taking the question in their own direction.[83] If the research was entirely empirical, this could have been an interesting route, but since the aim was in part to 'check' the doctrinal research, a semi-structured approach was necessary.

2.3 Analytic Strategy

The materials and methods used to analyse the collected data varied for the legal-doctrinal and empirical segments. Each phase of the performed data analysis is described here, establishing the basis for what will be presented in the Results section of Chapter 7.[84]

2.3.1 Doctrinal Analytic Strategy

The combined results of the legislative doctrinal review were synthesised in a traffic light table. The traffic light table presents an extensive list of all the laws and policy tools relevant to maximising the circularity of the life cycle of VFG and sludge materials. In the table, the different tools are marked as red, yellow or green at each institutional level to indicate whether they are present and whether they are being utilised. The table is only a 'first check' of whether the tool is present and not yet an assessment of whether the tool *should* be implemented because it contributes to the desired circular economy objectives. The first tools added to the table were those identified in the legislative and policy documents at all the relevant levels (EU, national, regional and local). After this, additional tools were added through a literature review.

The methodology for these segments combines the methodology of Oderkerk's descriptive, comparative and explanatory phases, because each 'state-of-the-art' segment *describes* the situation for both the Netherlands and Croatia and *explains* the similarities and differences between their two systems.[85] These descriptions and explanations form the basis for the end-goal, normative evaluation and possible recommendations (evaluative phase).

2.3.2 Empirical Analytic Strategy

The interviews were transcribed and coded as part of a blended thematic analysis approach. The transcription was 'intelligent' (not verbatim or edited), which means that every word was transcribed, but pauses, stutters and filler words ('erm', 'ah') were excluded. Coding was done using a blended

[83] Ansems (2022).

[84] Hahn, Fox & Jennings (2014) 17.

[85] Oderkerk (2015) 599.

four-step approach in NVivo, which combined inductive and deductive analysis techniques. The first round of coding was inductive open coding, the second was axial coding on the open codes from the first round, the third was deductive open coding (using the law and policy tools from the traffic light table as codes), and the final was a round of combined axial coding.

The first step, open coding or 'ground-up' coding, requires staying close to the data and deriving the codes and themes therein, rather than developing codes beforehand and searching for them in the data.[86] Inductive open and axial coding facilitated the thematic analysis because it allowed new themes to emerge across the qualitative data set. This helped to avoid bias, which can come about when only deductive coding from pre-set codes is performed. Furthermore, this type of analytic strategy best underlines the 'action and interaction strategies of the actors' interviewed, which is important for the present research that seeks to understand how the law is perceived and applied by different relevant actors in practice.[87] As such, this method provided information on how public stakeholders can facilitate the better application of circular methods in the recovery of organic matter from waste *and* what triggers private stakeholders to apply better circular methods in the recovery of organic matter from waste.

Following the first two rounds of open and axial coding, a round of deductive coding was performed using the law and policy tools from the traffic light table, identified through the legislative doctrinal part of the research. Each of the law and policy tools on the traffic light table was a code, and the research checked how many times each code was mentioned in interviews as a factor that needed reform (legislative or otherwise). This deductive coding step was important because it 'checked' whether the factors identified in the legislative doctrinal research were considered relevant in practise.

In this way, through blended coding and analysis, the themes that emerged from the interviews were cross-checked against the central themes that emerged from the theoretical research on the legislative state of the art. Together, these provided a *de jure* and *de facto* state of the art and a foundation for an evaluation of the biggest barriers and incentives to the recovery of organic matter from VFG and sludge waste streams.

2.3.3 Normative Evaluation & Recommendations

The two-fold evaluative method outlined above, in combination with the findings from the descriptive segments, provided an answer to whether the solutions driving forward this circular transition lie more at the EU-wide, nationwide or local level, which legislative and policy measures it lies

[86] M.S. Linneberg and S. Korsgaard. 'Coding qualitative data: A synthesis guiding the novice.' Qualitative research journal (2019).

[87] U. Kelle, '"Emergence" vs. "forcing" of empirical data? A crucial problem of "grounded theory" reconsidered.' [2007] Qualitative Social Research, 6(2), para 16.

with and also how different actors can influence a smooth transition. Together, the answers found in the various segments inform the recommendations for any modifications that should be made to law and policy at the EU and national levels to better facilitate the recovery of organic matter from waste streams.

2.4 Peer Review

The purpose of the peer review performed on this research was not to check the validity of the arguments presented but rather to check if all relevant pieces of legislation and policy were addressed. This approach was chosen because the breadth of this research was vast, requiring additional peer review to ensure that everything was covered. It was not necessary for peer reviewers to read the full manuscript (only the parts relevant specifically to their expertise), because supervision over the integrity of the manuscript as a whole was done by the supervision team – Ton van den Brink, Chris Backes and Miriam van Eekert. Ton van den Brink (Utrecht University) provided expertise on EU and institutional legislative issues. Chris Backes (Utrecht University) provided expertise on the circular economy in the context of European environmental law. While Miriam van Eekert (Wageningen University) provided expertise on the biotechnological aspects of this research.

To facilitate peer review, the chapters were divided into four sections: VFG Netherlands, Sludge Netherlands, VFG Croatia and Sludge Croatia. A peer reviewer was chosen for each section of the manuscript (from the legal-doctrinal parts), as follows:

Peer Reviewer	Manuscript Chapter
Aster Veldkamp	VFG Netherlands
Aster Veldkamp	Sludge Netherlands
Želimir Veinović	VFG Croatia
Anamarija Grbeš	Sludge Croatia

Table 1: Overview of peer reviewers and the chapter each person reviewed

Aster Veldkamp is an assistant professor at Utrecht University, with both academic and practical expertise in EU and Dutch environmental law and the circular economy. Her past work at the Rijkswaterstaat (Directorate General for Public Works and Water Management) was related to both VFG and sludge, to some extent. Želimir Veinović is an associate professor at the University of Zagreb, in the Faculty of Mining, Geology and Petroleum Engineering. His work is focussed on waste and touches on the relevant regulatory frameworks. Anamarija Grbeš is an assistant professor, also at the University of Zagreb, at the Faculty of Mining, Geology and Petroleum Engineering. Relevant to the present research, her work is relevant to environmental and resource management and the associated regulatory frameworks.

All peer reviewers were contacted purely on the basis of their expertise and agreed to perform the peer review on a voluntary basis. Additionally, they have a purely academic and scientific interest in the research and do not have personal interests in the research results or personal relation to the main researcher.

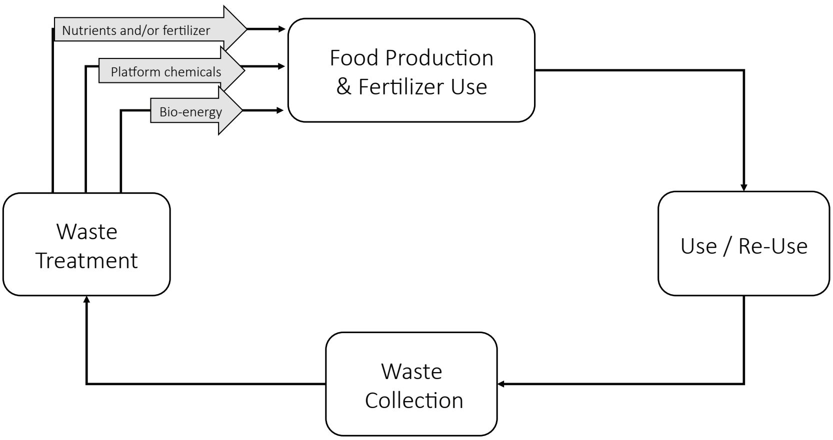
2.5 Ethical Approval and Informed Consent

The present research methods were approved by the Faculty Ethics Assessment Committee of Utrecht University. The interviewee selection process and interview methods were deemed in compliance with confidentiality, anonymity, informed consent and other academic ethical standards.

3 Reading Guide

This manuscript is structured in such a way that if follows the lifecycle of VFG and sludge waste materials (from production in agriculture through to treatment for recovery and the creation of new products from recovered materials). This lifecycle is explained in greater detail in Chapter 2 on the bio-technological and general state-of-the art surrounding VFG and sludge materials, but a simplified version looks like this:

Figure 4: A simplified version of the VFG and sludge materials' lifecycle



Chapter 2 'General and Biotechnological Practices around VFG and Sludge Waste Streams' explains the complete VFG and sludge materials' lifecycles, including where they diverge (in the 'collection' part) and where they partly converge (in the material feedback loops back into 'production'). Then, Chapter

3 on ‘EU Competence in Waste and Environmental Law’ attempts to explain the legal basis for EU and member state division of competence relevant to the entire lifecycle.

Chapter 4, on the initial ‘production’ part of the lifecycle begins the legislative analysis of these material streams, looking at the various legal areas and applied law and policy tools. It is the only part of the lifecycle that is the same for both VFG and sludge. As such, to avoid repetition, the legislative areas (critical raw materials and agriculture) relevant to this part of the cycle are discussed jointly in one chapter.

Chapter 5 is specific to the VFG materials’ lifecycle. It begins where chapter 4 left of, with ‘waste collection’ where the VFG and sludge material lifecycles diverge. It goes on to cover the legislative and policy tools relevant to treatment of VFG waste and the recovered material streams (products).

Chapter 6 is specific to the sludge materials’ lifecycle. It also begins where chapter 4 left of, explaining the legislative and policy tools related to sludge collection, treatment and recovered material streams (products).

Chapter 7 portrays the results of the empirical research component of the research. It presents the results of the inductive and deductive coding, and illustrates them with a series of direct quotes and examples from relevant interviews. Lastly, Chapter 8 brings together the doctrinal findings from Chapters 3, 4, 5 and 6 and the empirical findings from chapter 7 into a discussion and conclusion on the main barriers and incentives to the circular management of VFG and sludge resources.

CHAPTER 2

The General and Biotechnological State of the Art for VFG and Sludge Waste Streams

Before delving into the legislative analysis of topics relevant to the circularity of chosen waste streams, for the present topic it is essential to understand the bio-technological and purely logistical context of these materials' lifecycles. That is the central aim of this chapter.

The chosen waste streams for analysis are components of the bio-waste and sludge waste streams, which are the large fractions of European municipal solid waste. Bio-waste accounts for the largest fraction, 40% of European municipal solid waste,[1] but today only 30% of bio-waste across Europe is collected separately and recycled.[2] The EU Waste Framework Directive (herein: WFD) defines bio-waste as biodegradable garden and park waste; food and kitchen waste from households, restaurants, caterers and retail premises; and comparable waste from food processing plants.[3]

The focus of the present research is a fraction within the bio-waste stream: VFG (vegetable, fruit and garden waste). The contents of the stream are rather self-explanatory, consisting largely of food (vegetables and fruit) and various garden waste (grass clippings, hedge cuttings, leaves, wood, soil and stones). VFG relevant to the present research is given the waste code 20 01 08 under the European 'List of Waste'.[4] In addition to the materials that are supposed to be in this stream, VFG waste can also be contaminated with other materials, such as plastics. As with most waste streams, the EU is currently aiming to move toward more sustainable management of the bio-waste stream and VFG within that. The goal of policy and legislation in this area is to reduce the amount of VFG landfilled and increase the amount treated and reprocessed into new products.[5]

In the European Union, sewage sludge is defined as a by-product of wastewater treatment.[6] More specifically, it is the material left over after the treatment of domestic and urban wastewater, wastewater from wastewater plants and wastewaters of a composition similar to those.[7] Sludge relevant to the present investigation is given the waste code 19 08 05 under the European 'List of Waste'.[8] Though wastewaters can be mixed, containing both municipal wastewater and other wastewater of similar compositions (like industrial wastewaters), the present research focuses on the full lifecycle view only of municipal wastewater only, leaving out wastewater of an industrial origin. When it comes to the

1 European Compost Network, 'Biowaste in the Circular Economy' (Workshop Report, 2017).

2 European Compost Network (2017).

3 Waste Framework Directive (2018) Art. 3(4).

4 Commission Decision of 18 December 2014a, amending Decision 2000/532/EC on the list of waste pursuant to Directive 2008/98/EC of the European parliament and of the Council (2014/955/EEC) [referred to hereafter as 'The List of Waste (LoW)'].

5 European Commission, 'Closing the loop – An EU action plan for the Circular Economy' (Communication) COM(2015) 614 final.

6 Commission, 'Sewage Sludge' (European Commission Website, 7 August 2019b).

7 Council Directive 86/278/EEC of 12 June 1986 on the protection of the environment, and in particular of the soil, when sew-age sludge is used in agriculture (Sludge Directive) [1986] OJ L 181/6, Article 2(a).

8 Commission Decision (2014a).

recovery and recycling of materials from sewage sludge, more so than for VFG and other bio-waste, it is important to understand that there are positive and negative perceived aspects, particularly when it comes to application on agricultural land. Sewage sludge is considered valuable because it contains two recoverable components: energy and nutrients.[9] Sludge allows for the effective recycling of nutrients (thereby contributing to the conservation of their natural reserves) and is also a favourable replacement for chemical fertilisers.[10] Alongside use in agriculture, sewage sludge has been successfully applied in forestry and in land reclamation of disused mines and landfills.[11] Despite the possible positive applications, many valid concerns also exist about the use of sludge in agriculture, since sludge can contain compounds harmful to ecosystems and human health, such as heavy metals, organic pollutants (such as pharmaceuticals, nano- and/or micro-plastics and PFAS) and pathogens.[12]

Alongside these positive and negative perceptions from the point of view of the environment and health, it is also interesting to consider sludge from the perspective of wastewater treatment plants (WWTPs), to which sludge represents an expensive problem. Sludge treatment requires high amounts of energy, which is why it accounts for 'approximately 50% of the total running cost of WWTPs'.[13] In addition to this, sludge disposal processes are 'responsible for 40% of the total greenhouse gas emissions from WWTPs'.[14] This puts sludge in a precarious position, as it is a material which is expensive to treat, uses a lot of energy and causes the emission of a great deal of greenhouse gas; at the same time, when viewed through a circular economy perspective, sludge reuse offers a great opportunity to feed valuable resources (both energy and organic compounds) back into the economy. Sometimes, sludge can even replace other energy resources and limit the associated CO2 emissions.[15]

If we are to achieve the EU-wide recovery and circularity goals, we need to consider the full life cycle of materials held within VFG and sludge waste streams (from the point where they are foodstuff in the Earth absorbing nutrients, to the point where they are treated and reprocessed into products). In this research, life cycle thinking is applied in a slightly different way, in that it does not seek to account for the economic, environmental and social impacts across

9 D. Đurđević, P. Blecich and Ž. Jurić. 'Energy recovery from sewage sludge: The case study of Croatia.' Energies 12.10 (2019): 1927, 6-7.

10 A. Gendebien, 'Environmental, economic and social impacts of the use of sewage sludge on land' (Report for the European Commission, 5 August 2022), 20.

11 Gendebien (2010) 2.

12 This is especially the case when the sludge stems not only from municipal wastewater, but from a mix of wastewaters including industrial wastewater; L. Lamastra, N.A. Suciu and M. Trevisan. 'Sewage sludge for sustainable agriculture: contaminants' contents and potential use as fertilizer.' Chemical and Biological Technologies in Agriculture 5.1 (2018): 10; Gendebien (2010) 2.

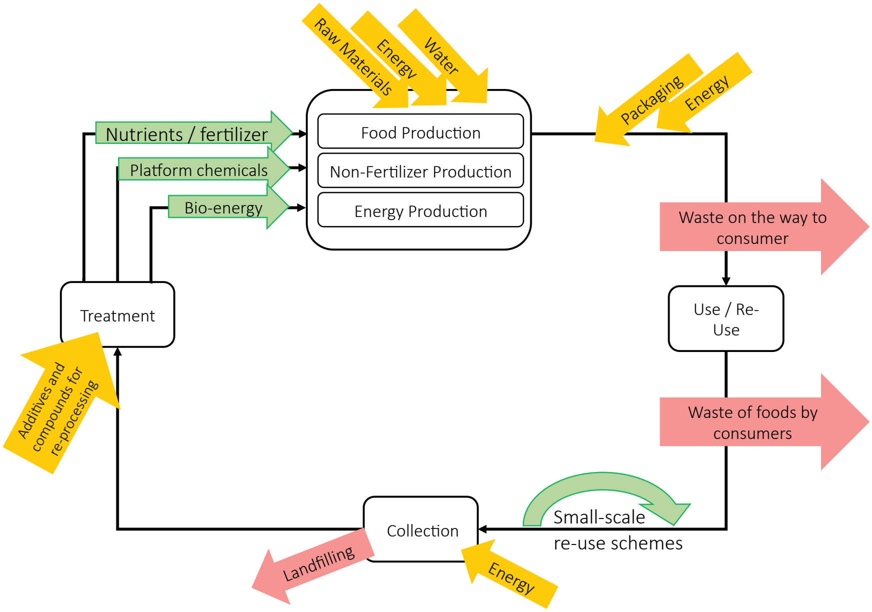
13 Gherghel (2019) 245.

14 Gherghel (2019) 245.

15 Gherghel (2019) 245.

all stages of a product's life cycle[16] – but instead seeks to map all the open loops and existing closed loops within the life of a product. A simplified life cycle of VFG and sludge materials comprises five stages: production of foodstuff, use, collection, recycling and finally the production of new products from the treated sludge (Figure 5). A deeper understanding of each of the four depicted stages (and the closed and open loops between them) will be provided throughout the first part of the following chapter. During the life cycle of these materials, there are plenty of opportunities for the closing of loops, but also for waste.[17]

Figure 5: Representation of VFG and sludge materials' life cycle



In the diagram, the red arrows represent waste, and the green arrows represent outputs that are fed back into the loop, creating the basis for what is hoped to eventually be an almost entirely closed-loop circular agricultural food system. The yellow represents inputs coming in from outside of the system. In an ideal

[16] Life Cycle Initiative, UN Environment & SETAC, 'What is Life cycle thinking' (2020).

[17] Same as for VFG, in Figure 1 the red arrows represent waste, and the green arrows represent outputs that are fed back into the loop, creating the basis for what is hoped will eventually be an almost entirely closed loop, circular system. The yellow arrows are also important to understand, as they represent inputs coming in from outside of the system – in an ideal scenario these yellow arrows would be minimized and most of these inputs would come from within the circle; EIT Raw Materials, 'Design of products and services for the circular economy' (2020).

scenario, the inputs would be minimised, and most of these inputs would come from within the circle.[18]

The label titled 'Additives and compounds needed for reprocessing' was intentionally kept broad to include all the different components that are necessary inputs for reprocessing methods, including not only (large amounts of) water but also substrates, chemicals, and any other substances that are currently necessary, or maybe necessary in the future, for reprocessing. A deeper analysis of these additives and compounds can be found in Section 1.1 of the present chapter.

The label 'small-scale reuse schemes' (in Figure 5) refers to the smaller scale, consumer-led reuse schemes like donation of unused food, home (or decentralised small-scale) composting and smaller digestion projects. These need to be distinguished from larger-scale reuse schemes in the reprocessing stage of the figure, which refer to industry-led composting and digestion projects. The former is discussed below under 'Use and Reuse', while the latter is discussed below under 'Reprocessing'.

The following five segments of this chapter (3.1, 3.2, 3.3, 3.4 and 3.5) will explain each of the stages from the above figure (production, use, collection, treatment and creation of new products) in further detail from a general and biotechnological perspective. The two chapters after this one will explain the legislative frameworks around each of the five stages (for VFG and sludge, respectively). Combined, these chapters provide the general and legislative theoretical background needed to understand the life cycles of the organic material contained within these two waste streams.

2.1 Production

The story of VFG and sludge actually does not begin in VFG containers in our kitchens or the toilets in our bathrooms, but even before that in the stage of 'Food Production', at the top of Figure 5. The food we eat, which eventually ends up in these waste streams, requires the input of raw materials as part of agricultural production. In agricultural production, raw materials are needed to create fertiliser blends, which are often very complex.[19] They can contain a dozen or more components, including nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulphur (S) and a series of micronutrients.[20] This means that mining and processing of raw materials is

[18] EIT Raw Materials, 'Design of products and services for the circular economy' (2020).

[19] International Fertilizer Industry Association, 'Mineral Fertilizer Use and the Environment' (United Nations Environment Programme, Paris, February 2000), 7; C.R. Cánovas, et al. 'Exploration of fertilizer industry wastes as potential source of critical raw materials.' Journal of Cleaner Production 143 (2017): 497-505, 497.

[20] International Fertilizer Industry Association (2000) 7; Cánovas (2017) 497.

part of the production process. A study on raw material use in the EU identified critical raw materials (herein: CRMs) as a new focus for waste policy:[21]

> 'CRMs do not typically generate high volume waste streams; however, they are significant when considering issues of material security, since the EU relies heavily on imports of many CRMs. They are therefore of value and importance to the EU economy, to EU industrial jobs, and to sustained economic growth within the EU. The European Commission report on critical raw materials (European Commission, 2014b) reports that, historically, the indispensable role of metals, minerals, rocks and biotic materials has had a low profile. However, more recently, securing reliable, sustainable and undistorted access to crucial non-energy raw materials has been of growing concern in economies such as those of the EU, USA and Japan.'

According to the Mineral Resources Expert Group, there are no critical raw material deposits in either the Netherlands or Croatia.[22] This means that both countries are dependent on other EU and non-EU countries for the import of the raw materials needed for their food production. Both countries would stand to benefit from a system restructuring that would facilitate them to recover the materials they need for food production from their own waste or waste produced within the EU.

This is particularly relevant for the Netherlands, which has been described as an 'agricultural giant',[23] producing around 11 million tonnes of fruit and vegetables per year for export.[24] To support this level of industrial farming, the Netherlands annually consumes about 288 kg of fertiliser per hectare of land.[25] In this case, fertiliser products cover carbon, nitrogenous, potash and phosphate fertilisers, while traditional animal and plant manures are not included.[26] Considering there are 1,028,000 hectares of arable land in the Netherlands,[27] the estimated consumption of fertiliser in only one year is around 300,000 tonnes. These numbers have been on the decrease since 2005, yet they are still staggering, and this is even before delving into further details, like nitrogen, phosphorus, potassium, magnesium and sulphur content of the applied fertiliser and the sourcing of these nutrients. Although not all of these nutrients are sourced from the naturally occurring critical raw material deposits (some are

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[21] Oakdene et. Al. (2017), 28; Commission, '2017 list of Critical Raw Materials for the EU' (Communication) COM(2017) 490 final.

[22] P. Handley, 'EU Critical raw materials in the circular economy and strategic value chains and EU R&D funding' (European Commission, January 2019).

[23] Frank Viviano, 'This Tiny Country Feeds the World' (National Geographic Website, September 2017).

[24] Food and Agriculture Organization of the United Nations, 'The Netherlands' (FAO Website, 2020).

[25] Knoema, 'Netherlands – Fertilizer consumption per unit of arable land' (Knoema Website, 2016).

[26] Knoema (2016).

[27] Trading Economics, 'Netherlands – Arable Land (hectares)' (Trading Economics Website, 2020).

sourced, for example, from manure),[28] recovering some of these materials from waste would greatly ease the pressure for their mining and processing from natural sources.

The situation is similar in Croatia. Croatia produces around 300,000 tonnes of fruit and vegetables per year on its 863,360 hectares of arable land.[29] To support this production, in 2016 Croatia used 119.3 kg of fertiliser per hectare. The level of consumption continues to fluctuate year-to-year. Although Croatia's annual production of fruits and vegetables is smaller than that of the Netherlands (on relatively similar amounts of arable land), production of fruits and vegetables could also be supported by waste-derived fertiliser ingredients recovered from waste.[30] These could be produced within Croatia's own borders, would reduce the pressure of importation costs of fertilisers, and could allow Croatia to grow its agricultural sector and make better use of its plentiful hectares of arable land.

In addition to considering the raw materials that go into production, circular production also includes product design. This means designing products in such a way that they can be easily reused (whole or in parts), prolonging their life through maintenance and repair, as well as the use of recyclables or recovered materials from waste flows in the production process.[31] As food-products that end up in VFG and sludge stream are not designed, per se, this element of circular thinking is of little relevance. However, the production methods used to grow and harvest food materials are highly relevant and presently, not very circular.

To take vegetables as an example, the process of growing vegetables (in an industrial context) utilises high levels of inputs (water, energy, fertiliser, etc), a large portion of which are not converted into edible products.[32] This model does not effectively use resources, resulting in wasteful and environmentally damaging outcomes. For example, millions of hectares of forest are cut down to make room for agricultural plantations, while at the same time, on average, 30% of all food produced does not make it to a consumer's plate.[33]

As such, a circular economy in the production and use of food centres on using a minimal amount of external inputs, closing nutrient loops and reducing

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28 Janjo de Haan & Wim van Dijk, 'Fertilization and fertilizers use in the Netherlands' (Wageningen University, March 2015).

29 Bas Janssens and others, 'Croatian Fruit and Vegetables Sector at a Crossroads' (Wageningen University Presentation, 8 November 2017) 4, 7.

30 Janssens et. al. (2017) 44-49.

31 N. Van Buren, et. Al., 'Towards a circular economy: the role of Dutch logistics industries and governments' (2016) Sustainability 8(7): 647.

32 T.A. Toop et. Al., 'AgroCycle–developing a circular economy in agriculture' (2017) Energy Procedia 123: 76-80, 78.

33 Nick Jeffries, 'A circular economy for food: 5 case studies' (Ellen MacArthur Foundation, 9 February 2018).

negative discharges to the environment (in the form of waste and emissions).[34] The goals of minimal external inputs and closing nutrient loops are closely related. Nutrient loops can be closed by recycling nutrients from waste streams and using them in agricultural production (as fertilisers, soil amendments, mulches), which would at the same time reduce the amount of external input to the process in the form of chemical fertilisers that are dependent on raw materials from the Earth.

2.2 Use

The use of products is the stage in the circularity figure most relevant for consumers, but it also applies to use in an industrial context. Even though food waste occurs in all stages of the food production and supply chain, individual domestic food waste is the largest contributor.[35]

Optimal use is important because it ensures that a product or resource is maximally depleted before being discarded or recycled. Optimal use, as it relates to VFG and sludge, includes minimising food waste (re-purposing scraps, consuming leftovers), the consumption of imperfect foods (foods which are misshapen, slightly blemished or in any other way failing to meet strict cosmetic requirements[36]), as well as reuse (creating animal feed, composting, etc). Consumers can be involved in small-scale community composting and digestion projects which form one of the first feedback loops in the CE cycle, labelled 'small-scale reuse schemes' in Figure 5. The Use and Reuse stage of the CE product life cycle is largely consumer-focussed and therefore falls slightly outside the scope of the present research. As such, the legislative segment will not have a specific 'Use and Reuse' section, but will instead cover the relevant legislative areas, such as food law and public health interests, when discussing the products that result from treatment.

Use and reuse are, however, slowly becoming more relevant at the producer level. For example, in the Netherlands, a big supermarket chain (Jumbo) has started selling products made with food that otherwise would have been wasted, by selling it in the form of soups, chutneys and other products. These products reused 'wonky vegetables, beer from stale bread, cider from blemished apples, and soaps from discarded orange peels'.[37] This is not yet happening nationwide, with only a few selected stores in one city offering these products, but if it is

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34 AgroCycle, 'The 'circular economy' applied to the agri-food sector' (2017) (European Commission DG Research and Innovation Science Policy Dialogue, 16 October 2017, Brussels).

35 Matthew Chidozie Ogwu, 'Understanding the Composition of Food Waste' in Aparna B. Gunjal and others (eds), Global Initiatives for Waste Reduction and Cutting Food Loss (IGI Global, 2019), 212-236, 217.

36 Mark Esposito, Terence Tse & Khaled Soufani, 'The Circular Economy Takes on Food Waste' (Stamford Social Innovation Review. 1 April 2016).

37 Thin Lei Win, 'Netherlands turns food waste into new products' (CS Monitor, 30th March 2018).

successful, it could be a model for reuse on a larger scale in the future.[38] Reuse is a responsible approach because the intended function of the products (to serve as food for humankind) is maintained. These types of reuse schemes contribute to the 'reduce' and 'reuse' components, of the waste hierarchy – which are a top priority.[39]

2.3 Collection

The collection phase is where the stories of VFG and sludge waste streams, and the organic matter held therein, begins to diverge. The two waste streams leave the consumer in separate ways: one through VFG bins in kitchens and the other through toilets and the sewage system.

2.3.1 Collection of VFG

Following optimised product use and reuse, the remaining VFG 'waste' must still be deposited by the consumer prior to collection and further treatment. At the point where the consumer disposes of the foodstuff (and garden plants), the materials become VFG waste. Following this, VFG waste can be collected in a separate or centralised manner and then transported to the relevant facilities.

Collection systems for bio-waste, such as VFG, still vary widely among the EU Member States. Studies have shown that separate collection of VFG waste increases the overall amounts of separately-collected waste, thereby being more aligned with the EU's recycling targets.[40] Furthermore, the studies found that 'the higher the volume of separately-collected organic waste, the higher the incentive to set up systems to treat the waste in an efficient manner and to achieve the best economical and environmental outcomes'.[41] Other studies, at a more global level, also emphasise the importance of source separation of VFG waste, outlining how source separation 'not only produces a better product quality but also makes the public more aware of the necessity of waste reduction and waste separation'.[42]

Sustainable treatment of VFG primarily requires VFG to be separated from residual waste at source.[43] Source-separated VFG waste can either be composted

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38 Lei Win (2018).

39 Esposito, Tse & Soufani (2016).

40 European Bio-plastics, 'The benefits of separate organic waste collection' (2016).

41 Ibid.

42 A.H.M. Veeken, P. Hamminga and Z. Mingshun, 'Improving sustainability of municipal solid waste management in China by source separated collection and biological treatment of the organic fraction' Innovative environmental management & sustainable development (2005). 164-172.

43 European Environmental Agency, 'Bio-waste in Europe — turning challenges into opportunities' (EEA Report, 2020), 14.

at home or collected for treatment at a centralised treatment plant. Even though home composing has largely the same GHG emissions as composing plants,[44] it decreases the need for collection and thereby also the associated transport and management of environmental impacts (and municipal costs).[45]

However, if VFG is to be collected for treatment at a centralised treatment plant, the first step is to ensure VFG is actually collected, because uncollected bio-waste can cause contamination as a source of uncontrolled pathogens and bio-aerosols.[46] If VFG is collected through centralised collection, it can eventually be used as fuel for energy from waste plants or utilised in mechanical biological treatment facilities.[47] If VFG is collected separately, larger quantities of it can be used in open air windrow or in-vessel composting and anaerobic digestion plants.[48] Although it is also possible to collect and separate centrally and then digest the remaining organic fraction. Despite this, separate collection does contribute to improving the 'recycle' and 'recover' steps of the waste hierarchy.

The second step of collection is to transport VFG to treatment centres. The introduction of separate bio-waste collection usually requires an initial investment by the public sector, but 'cost-benefit analyses have shown that the overall economic outcome for both citizens and the waste management organisation is positive'.[49] The actual costs depend on many factors, including the chosen collection system (door-to-door collection or containers on the roadside), population density, collection frequency and weather conditions. Additionally, VFG should be transported to treatment centres, but the growth in transport kilometres should be limited as this reduces logistic costs and is directly beneficial to the environment.[50] The literature deems one important way of ensuring this limited growth to be intensifying collaboration between transport companies.[51] Such collaboration would allow shared transport means and an increase in the load factor of transport modes. This type of collaboration could be supported by strengthened policy efforts to stimulate 'spatial clustering of industries that are (increasingly) dependent upon each other',[52] for example, by bringing together linking infrastructures (for reusable wastewater or heat) and shared services (shared waste treatment, quality and safety control, renewable energy production, distribution, etc).[53] Since revising the logistics of transport systems

44 J.K. Andersen, et al. 'Greenhouse gas emissions from home composting of organic household waste.' Waste Management 30.12 (2010): 2475-2482.

45 European Environmental Agency (2020) 14.

46 Environmental Services Association, 'Biowaste in a Circular Economy' (ESA UK Report, September 2014) 8.

47 Environmental Services Association (2014) 8.

48 Ibid.

49 European Environmental Agency (2020) 17.

50 Van Buren et. Al. (2016) 10.

51 Ibid.

52 Ibid.

53 Ibid.

would reduce the amount of energy and fuel needed to transport waste, it would contribute to the 'reduce' step of the waste hierarchy.

Both Croatia and the Netherlands provide several types of collection systems, usually differing by region or by city. The main collection types used are door-to-door collection and bring points.[54] Separate collection is attempted and encouraged in both Member States, but full separate collection of waste streams like VFG is not yet complete in either Member State.[55]

In the Netherlands, out of the 140 kg of VFG waste generated per person per year, 87 kg per person are collected separately.[56] The Netherlands had a head start when it comes to separate collection and treatment, compared to some other European countries. Due to a lack of space for waste landfilling and growing environmental awareness, the Dutch government was pressed to begin finding alternative solutions in waste management as early as the 1980s.[57] Since 1994, the Netherlands has had systems of kerbside waste collection in place, as well as requiring municipalities to provide the necessary collection and recycling systems for the separate collection of glass, paper and textiles.[58] However, past studies have shown that there is significant variation between municipalities when it comes to how much of the collected waste is reprocessed.[59]

The established method is to separate this waste into drop-off containers that are collected periodically and taken to a central large-scale processing plant, where (in most cases) compost is made. Improvement is possible in several areas. For example, too much organic material still ends up in residual waste (on average, residual waste contains 32% organic waste).[60] This is often because existing infrastructure (ex: high-rise buildings) does not allow for separate collection of that many waste streams. However, it still leaves room for improvement of collection via entirely different waste collection systems, such as having food grinders in the kitchen sinks of apartments in such buildings. This solution has already been implemented in some areas such as in Noorderhoek (Friesland) and with Project H+ in Helsingborg (Sweden).[61]

In Croatia, most VFG is currently landfilled. It is collected, avoiding the nuisances of uncollected biological waste; however, its landfilling, although safe, does not allow for the material's full potential to be utilised. The estimated quantities of VFG produced have not changed much since 2012 and, on average,

54 European Commission, Environmental DG, 'Assessment of separate collection schemes in the 28 capitals of the EU' (DG ENV Report, 13 November 2015), 12.

55 European Commission, Environmental DG, 12.

56 Milieu Centraal, 'Afval scheiden: cijfers en kilo's' (2020).

57 E. Dijkgraaf and R. Gradus, 'An EU recycling target: what does the Dutch evidence tell us?' [2017] Environmental and Resource Economics 68(3), 502.

58 Ibid.

59 Ibid.

60 LeAF Report, 'Kleinschalige verwerkingsmethoden voor gft en swill – bijdragen aan de circulaire economie binnen bestaande regelgeving en beleid.' (March 2020) 1.

61 E. Kvarnström, 'Food and Energy in a Circular Economy' (City of Stockholm, 2017), pp. 3, 10.

constitute around 530,000 tonnes.[62] Of the 42,121 tonnes of separately-collected bio-waste, 83% was waste from gardens and parks, while the rest was biodegradable waste from industry kitchens and canteens, edible waste oils and market waste.[63] This means that relatively little household biodegradable waste (which would be the equivalent of Dutch VFG, is separately collected). Biodegradable waste from household kitchens is collected separately in only one county (Primorje – Gorski Kotar County, island of Krk).[64] Even though 'efficiency of separate bio-waste collection systems tends to improve with a systems' maturity, there have also been a number of cases in which Member States managed to achieve rapid improvements in separate collection 'over a relatively short period of time'.[65] It is hoped that the present research, and similar research, could facilitate Croatia in achieving these rapid improvements.

2.3.2 Collection of Sludge

Sludge is related to wastewater treatment, so wastewater collection is where our story continues following production/use. The treatment of urban wastewater is key to safeguarding public health and the environment.[66] Following the implementation of the Urban Waste Water Treatment Directive in 1991, EU Member States had to significantly improve their wastewater treatment systems. Treatment of wastewater in the EU follows a four-tier scheme: purely collection, collection with primary treatment, then (potentially) secondary treatment and, finally, tertiary treatment.[67]

The first level, simply collection, requires the resident population to be connected to a sewage collection system.[68] The primary treatment that follows collection and is sometimes also called 'mechanical treatment', requires the removal of some suspended solids in the wastewater through methods like settling.[69] This is followed by secondary, or 'biological', treatment, which applies aerobic or anaerobic microorganisms to decompose most of the organic matter and retain some of the nutrients.[70]

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[62] Government of the Republic of Croatia, 'Waste Management Plan of the Republic of Croatia for the period 2017-2022' (2017), 17-18.

[63] Croatian Agency for the Environment and Nature (2018) 23.

[64] Ibid.

[65] European Environmental Agency (2020) 20.

[66] European Environment Agency, 'Urban waste water treatment in Europe' (EEA Website, 2017).

[67] Urban Waste-water Treatment Directive [1991] Art 2(7).

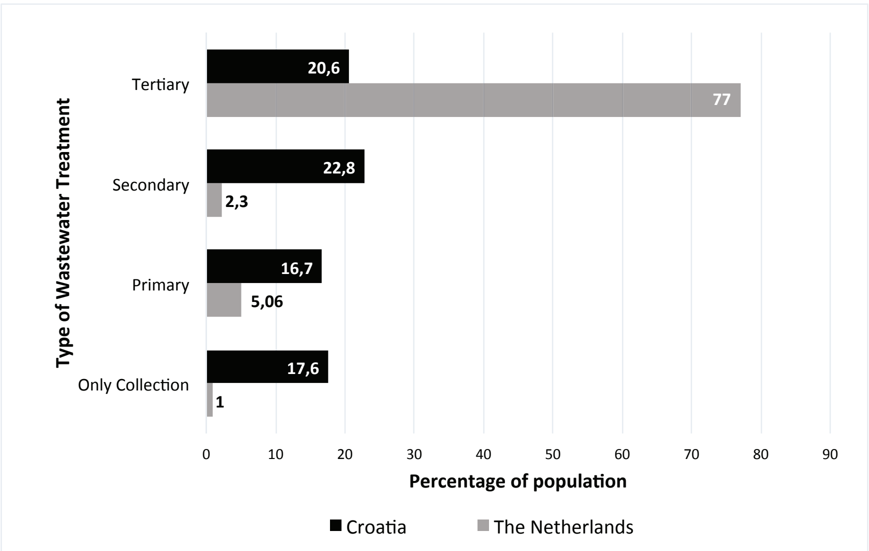
[68] Resident population connected to wastewater collection and treatment systems reported to the 'OECD/Eurostat Joint Questionnaire – Inland Waters-2012', European Environment Agency, 'Resident Population Connected to Wastewater' (EEA Website, 2012).

[69] Ibid.

[70] Ibid.

Finally, tertiary, or 'advanced', treatment can be applied to remove organic matter resulting in the recovery mainly of mainly nutrients.[71] The quality (composition) of the raw sewage sludge, as well as treatment technologies in WWTPs influence the final characteristics of the sludge, and thereby also the recovered product streams.[72] The sludge treatment process is described in a diagram in Appendix 1, and the prevalence of the various treatments in the Netherlands and Croatia is depicted in Figure 6.

Figure 6: 2015 Eurostat data on percentage of population connected to various types of urban wastewater collection/treatment systems[73]



Eurostat statistics from 2015 indicate that in Central Europe, including the Netherlands, 77% of the population was connected to wastewater collection and tertiary treatment systems. Meanwhile, 2.3% of the population was connected to secondary treatment, 5.6% was connected to primary treatment and only 1% of the population was connected merely to a collection system. Consequently, a large majority of the wastewater is maximally treated, with a great potential for the recovery of organic matter.

In the same year, but for South-eastern Europe, including Croatia, 20.6% of the population was connected to a wastewater collection system that allows for tertiary treatment to take place. While 22.8% of the population was connected to secondary treatment, 16.7% to primary treatment and 17.6% to only a

71 Ibid.

72 Gherghel (2019) 245.

73 European Environemntal Agency, 'Urban waste water treatment in Europe' (EEA Website, 2020).

collection system. These numbers respect the targets set in the Wastewater Treatment Directive (for 2000 and 2005),[74] but they also reveal the relative underdevelopment of Croatia's public wastewater system. The underdevelopment is evidenced in the fact that only 55% of the population is connected to the public wastewater systems and that large differences do exist between urban and rural areas.[75] While the Eurostat numbers are regional estimates for the regions to which the two Member States belong, they are, nevertheless, interesting indications of the different roads ahead in the nutrient recovery transition process for these two countries.

The usual technological scheme for collection of sludge within a wastewater treatment plant includes the following: separation of sludge from primary, secondary and tertiary stages of wastewater treatment; mechanical or mechanical thickening; aerobic or anaerobic stabilisation; dehydration to 20 – 30% dry matter; and removal from the WWTP for possible additional treatment or application of additional treatment at the WWTP itself.[76]

National Quantities of Sewage Sludge

Even with present day systems, after wastewater collection and treatment, it is currently estimated that the EU countries produce around 10.13 million tDS (total dry substances) of sewage sludge.[77]

In 2020, the Netherlands collected roughly 354 thousand tonnes of sewage sludge.[78] Dutch municipalities are mainly the competent authorities when it comes to public sewage systems, while the management of public WWTPs and the quality of surface water are the responsibility of the water boards (water management associations).[79] The Rijkswaterstaat (Directorate General for Public Works and Water Management), the water boards and the NVRD are the relevant authorities. The NVRD (the Royal Association for Waste and Cleaning Management) unites the Dutch municipalities and the public companies that are responsible for waste management and public space management – including wastewater management.

In 2016, Croatia collected 22.51 thousand tonnes of sewage sludge. Following planned expansion and upgrading of the wastewater treatment system, the amount of sewage sludge is soon expected to reach 100,000 tonnes.[80] The

74 Urban Waste-water Treatment Directive [1991]; 'The coverage rate for the public wastewater system is an average 75% in cities with more than 150,000 people equivalent (PE) but only 5% in small towns with less than 2000 PE.' Đurđević, Blecich and Jurić (2019), 5.

75 Đurđević, Blecich and Jurić (2019), 5.

76 N. Domazet, 'Otpadni mulj – problem bez jednoznačnih rješenja, ali s mnogim prilikama' (Energetika Website, 14.01.2022).

77 Gendebien (2010) 2.

78 Eurostat, 'Sewage sludge production and disposal' (Eurostat Website, 10 August 2022).

79 Rijkswaterstaat, 'Implementation EC Urban Wastewater Treatment Directive' (Rijkswaterstaat Website, 2023).

80 Đurđević, Blecich and Jurić (2019), p. 3.

Croatian local self-government and regional self-government units are the competent authorities when it comes to collection of wastewater and sewage sludge. Meanwhile, the Ministry of economy and sustainable development (Hr: Ministarstvo gospodarstva i održivog razvoja, herein: MINGOR) is the competent authority for oversight of wastewater management at the national level in cooperation with the Ministry of Agriculture (Hr: Ministarstvo poljoprivrede).[81] In addition, the Council for water services supervises the work of water service providers and keeps records on water services and providers.[82]

2.4 Treatment (Recycling, Recovery, Reprocessing)

The benefits described above of VFG and sludge collection can only be reaped if these streams are properly treated. There are many ways in which VFG and sludge can be treated and this is also reflected in the varied terminology of the EU in this area: 'treatment', 'preparation for reuse', 'recovery' and 'recycling'. 'Treatment' is a broad term encompassing any recovery or disposal operations, including preparation prior to recovery or disposal.[83] 'Preparing for reuse' refers to any recovery operations (including checking, cleaning or repairing) by which products that have become waste are prepared so that they can be reused without any other pre-processing.[84] Generally, both VFG and sludge are not applied as such (without any treatment) on farmlands or used in other products. Instead, they are usually treated for recovery. 'Recovery' is 'any operation the principal result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy'.[85] Lastly, 'recycling' means 'any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes'.[86] This includes the reprocessing of organic material, such as sludge and VFG, but does not include energy recovery.

Treatment and recycling of VFG and sludge waste offers public health, environmental and economic benefits through the conversion of 'waste' into a hygienic product, diversion from landfills, as well as the provision of valuable materials and possible revenue.[87] In addition to the environmental benefits

81 Zakon o vodama NN 66/19, 84/21, 47/23, Article 2(12), 78(1), 25(1): Pravilnik o gospodarenju muljem iz uređaja za pročišćavanje otpadnih voda kada se mulj koristi u poljoprivredi NN 38/2008), Annex II.

82 Ibid.

83 WFD, Art 3(14).

84 WFD, Art 3(16).

85 WFD, Art 3(15).

86 WFD, Art 3(17).

87 C.R. Lohri, et. Al., 'Treatment technologies for urban solid biowaste to create value products: a review with focus on low-and middle-income settings' (2017) Reviews in Environmental Science and Bio/Technology 16(1) 81.

discussed in the Introduction, reprocessing can also represent a significant part of a nation's 'job growth' (employment) strategy, as reprocessing is a labour-intensive process, requiring a wide range of knowledge and skills (if encouraged appropriately).

This research focussed on treatment methods relevant to the recovery of four different valuable materials held within VFG and sludge streams: nitrogen (N), phosphorus (P), potassium (K) and carbon-based compounds (such as PHA). Nitrogen, phosphorus and potassium are all macronutrients. The carbon-based compounds addressed are platform chemicals (volatile fatty acids, succinate, etc), while N, P and K are bio-based fertilisers high on the bio-based pyramid. These were selected because they are economically and nutritionally valuable compounds.

At the industrial level, various treatments can be applied to recycle and recover material waste streams from VFG and sludge: biological treatment, physico-chemical treatment or thermo-chemical treatment. Some treatments can be applied to both VFG and sludge, while others are specific to each waste stream. Treatments that can be applied to both are explained in this section of the chapter, while stream-specific treatments are explained further along (in Section 3.4.1 for VFG and in Section 3.4.2 for sludge).

In addition to treatment, there are some direct application possibilities relevant to waste that should also be understood in the context of VFG and sludge. The first is direct land application, the practice of spreading raw waste on fields where it undergoes natural aerobic biodegradation. This is an environmentally hazardous practice and is not practiced in most parts of the world for either sludge or VFG.[88] Other direct applications are as animal feed and in direct combustion. Sewage sludge cannot be used in animal feed, but VFG waste can be used, though there are risks with respect to the substances contained in VFG waste. As such, to mitigate potential risks or enhance its nutritional value, VFG is often treated before being fed to animals – meaning that it is applied primarily directly only at the decentralised-household level.[89] Direct combustion, or open burning, refers to 'a wide range of uncontrolled waste combustion practices including burning of waste in backyards or dump sites'.[90] This method is commonly applied in low and middle-income settings worldwide, as it requires practically no technical knowledge, is cheap and is the easiest way to make waste go 'away'.[91] The present research does not acknowledge it as a possible treatment solution due to the declaration of the Stockholm Convention as an 'environmentally unacceptable process', its illegal status under the EU's common agricultural policy of its low standing in the waste hierarchy. As such, none of the three different types of direct application are feasible uses of VFG and sludge waste streams.

[88] Lohri (2017) 86.

[89] Lohri (2017) 87.

[90] Lohri (2017) 88.

[91] Ibid.

Moving beyond direct application, the first group of treatments to be addressed in biological treatment. Biological treatment processes are controlled bio-conversion processes of waste involving living organisms (such as micro-organisms or worms). The most familiar of these processes is composting, the microbial conversion of organic matter into a humus-like material, most commonly used to enhance soil properties.[92] Composting is relatively easy and cost-effective to implement at the local and regional level,[93] which is why it is done at both the industrial level and (for VFG) as part of consumer-led, small-scale reuse schemes. During the composting process, microorganisms (in cooperation with higher organisms such as worms, beetles, mites) break down organic matter and produce carbon dioxide, water and heat.[94] Compost, the end-product of composting, 'contains important plant nutrients such as nitrogen, potassium, and phosphorus, although usually in different concentrations and or ratio's as animal manure or chemical fertilisers'.[95] Impurities in compost can be removed by sieving.[96] One drawback is that composting converts a lot of carbon (C) into carbon dioxide (CO2), which means the carbon is no longer available for recovery. 'Home' or 'backyard' composting refers to a generally cooler aerobic breakdown of organic material in small-scale composters.[97] Temperatures are in lower ranges than in industrial composting (rendering a product that is not considered hygienically safe *per se*), and the volume of waste treated in home composting is considerably smaller.[98]

Another biological treatment option that can be applied to both VFG and sludge is vermicomposting, a method that utilises microbes, and predominantly worms for the decomposition of solid organic waste into useful organic manure.[99] Worms can 'process household waste, organic municipal waste, sewage sludge and organic waste residues from different (paper, wood and food) industries' – with the exception of some food waste, including VFG.[100] The nitrogen content of vermicompost is comparable (usually 1–2% higher) to regular compost, and nutrients are reported to be more easily available to plants.[101] Another product of vermicomposting are the worms themselves, which are rich in protein (65%) and contain all the essential amino acids.[102]

92 I. Pan, B. Dam and S. K. Sen, 'Composting of common organic wastes using microbial inoculants', 3 Biotech 2(2) (2012): 127-134.

93 Lohri (2017) 89.

94 Ibid.

95 Lohri (2017) 90.

96 Ibid.

97 European Bioplastics, 'Home Composting Factsheet' (European Bioplastics Factsheet, April 2015) 3.

98 European Bioplastics (2015), p. 3.

99 T. Kaur, 'Vermicomposting: An effective Option for Recycling Organic Wastes' (2020) *Organic Agriculture Intech Open*.

100 Lohri (2017) 91.

101 S. Adhikary, 'Vermicompost, the story of organic gold: a review' (2012) Agric Sci 3(7): 905–917.

102 Lohri (2017) 92.

Worms can be used as a probiotic animal feed, provided they comply with the set limitations for heavy metals. Vermicomposting systems are 'considered less energy consuming, more cost-effective and economically feasible when compared to conventional treatment technologies'.[103] Nevertheless, vermicomposting is not a widespread approach in waste treatment and, from a legal perspective, the product is categorised as 'animal manure'.

Black soldier fly treatment (herein: BSF treatment), which involves the transformation of bio-waste into larvae and residue, is another process resulting in a product that is considered animal manure.[104] The larvae can additionally be used to make insect protein and (after refining) also insect oil. Both products can be defatted and made into a replacement for fishmeal in animal feed due to their high protein content and amino acid profile.[105] Suitable waste sources for BSF treatment are varied, but specifically relevant to the present research, BSF larvae can be fed with food and market waste, such as vegetables and fruit, but cannot process highly cellulosic waste (such as wood and dry leaves).[106]

Another option is anaerobic digestion, a well-established engineered process that biochemically decomposes 'both liquid and solid organic matter by various bacterial activities in an oxygen-free environment'.[107] Anaerobic digestion produces energy in the form of biogas and a product, digestate, which can be separated into a solid and a liquid fraction. It is essentially a pre-treatment. The biogas can be burned in stoves or lamps or be converted to electricity in gas generators or CHPs (combined heat power plants). The resulting digestate as a whole is rich in nitrogen and phosphorous and can often be utilised as a nutrient fertiliser or organic amendment. The digestate can be used (e.g. in agriculture) but often (depending on the substrate), the solid and liquid fractions may be separated to facilitate further use. Compost and struvite are produced from the solid fraction, as well as from platform chemicals (usually large platform chemicals such as volatile fatty acids or succinate). Of course, the end-product's composition is highly dependent on the nature of the waste fractions used in anaerobic digestion (herein: AD) process. Residues of different nature can be used, including VFG and sludge.[108]

Compost production and AD, both mature technologies, go hand in hand: according to the Compost Network, the establishment of a composting and anaerobic digestion infrastructure 'provides a solid basis of bio-waste management, to which novel technologies can be coupled', such as processes in which waste serves as a source of bio-based chemicals, fibres and nutrients.[109]

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[103] Ibid.

[104] Lohri (2017) 93.

[105] Ibid.

[106] Ibid.

[107] Ibid.

[108] Lohri (2017) 96.

[109] European Compost Network, 'Bio-Waste Management plays a Keyrole in Bioeconomy' (2020).

There are also physico-chemical treatment options that are relevant for both VFG and sludge. These treatments are essentially conversion processes, which are induced by chemical reactions or apply physical, mechanical force.[110] Densification is the physico-chemical treatment option most relevant for raw bio-waste and is a pre-treatment step for pyrolysis and gasification, which are thermo-chemical treatments (discussed below).[111] Densification of biomass is a mature technology.[112] The process involves the compaction of biomass through the application of mechanical force and binding agents, resulting in homogenous pellets, which can be used as a cooking fuel. In addition to this, densification also results in a liquid fraction, which contains a lot of nutrients such as nitrogen and phosphate that can be used in recovery.

Finally, thermo-chemical treatment processes 'apply heat to induce chemical reactions as a means of extracting and creating energy carriers as products'.[113] Energy from biomass can be transformed into fuels in either a solid (charcoal), liquid (bio-oils), or gaseous (syngas) form, through the treatment processes of pyrolysis, liquefaction, or gasification'.[114] Thermo-chemical processes require substantial energy input, which offsets some of the circularity benefits.[115]

Pyrolysis is essentially the use of heat to decompose biomass in the absence of oxygen.[116] Pyrolysis can be slow (where the main output is char) or fast (where the outputs are bio-oil and a non-condensable vapour called syngas).[117] The other two outputs (bio-oil and syngas) are essentially energy sources. The materials fed into the (either slow or fast) pyrolysis processes should be 'dry, unmixed, homogeneous, uncontaminated substrate, preferably with high carbon and low ash content, available at no or low costs'.[118] Char can be used as a fuel, a soil conditioner or a precursor for making catalysts and contaminant adsorbents.[119] The other two thermo-chemical processes, liquefication and gasification result, respectively, in bio-oil and gas, which are energy sources and thereby not the central focus of the present research.[120] Having said that, the creation of ashes is actually an important recovery route for P recovery from some waste streams (such as sludge).

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110 Lohri (2017) 100.

111 Lohri (2017) 100-103.

112 Lohri (2017) 103.

113 Lohri (2017) 104.

114 Ibid.

115 Ibid.

116 Ibid.

117 Ibid.

118 Lohri (2017) 107.

119 Lohri (2017) 105.

120 Energy recovery is not the focus because it is the least desirable option for extracting value from resources. As explained by Van Buren et al., 'recovery of energy actually 'ends' the resource-cycle by degrading and decomposing materials into heat, emissions and ashes', Van Buren (2016), 647.

2.4.1 Treatment of VFG

At the moment some treatment routes and considerations are specific to each waste stream, for VFG these are discussed here. A treatment method complementary to AD for VFG treatment is fermentation, specifically Bokashi fermentation.[121] Fermentation is an anaerobic process similar to anaerobic digestion. Bokashi is essentially the digestion process interrupted at the fermentation (acid-forming) stage, leading to conservation of the organic matter.

The microbes that 'power' Bokashi mostly use readily biodegradable organic matter as their food source and convert that to organic acids.[122] As a result, the pH lowers and the remaining organic matter is conserved (similar to, for example, sauerkraut fermentation). Food waste and VFG specifically are found to be highly suitable materials for Bokashi fermentation. The end-product has more or less the same elemental composition as the starting material because the process is sealed and gaseous products (e.g. CO2) that are formed cannot escape. Once the end-product comes into contact with oxygen, decomposition starts right away. There has been relatively little study on the possible hazards associated with the fermented product (especially when compared to compost).[123]

A lot of reprocessing of household waste is done through mechanical biological treatment (herein: MBT). MBT plants process mixed household and industry waste, as opposed to separately collected waste streams.[124] The reprocessing works by combining a sorting facility with a form of biological treatment, anaerobic digestion and/or composting. The resulting products are refuse-derived fuels (RDF/SRF) and a stable organic component that can be disposed of in a landfill, or under certain conditions, used as a soil improver.[125]

In the Netherlands, reprocessing has been evolving positively, with more than 50% of generated municipal waste undergoing some kind of reprocessing.[126] For VFG specifically, around 1.3 million tonnes are reprocessed yearly; however, this is only around 20% of the total amount of VFG generated.[127] The small portion of collected municipal waste is still being incinerated (80 of the collected 8,203 million kg2 in 2018).[128] Incineration is a thermal waste treat-

[121] Charles N. Merfield, 'Treating food preparation 'waste'by Bokashi fermentation vs. composting for crop land application: A feasibility and scoping review' (2012) Report commissioned by Gisborne District Council. Canterbury: Lincoln University, 1.

[122] Merfield (2012) 5.

[123] Ibid.

[124] This also takes place in the Netherlands, for example at OMRIN in Harlingen; Croatian Agency for the Environment and Nature (2018) 35.

[125] Croatian Agency for the Environment and Nature (2018) 35.

[126] Leonidas Milios, 'Municipal waste management in the Netherlands' (European Environmental Agency, 2020), 10.

[127] Milios (EEA, 2020), 10.

[128] Government of the Netherlands, 'Waste generation and treatment by sector, 1990-2018' (CLO Website, 6 November 2020).

ment process, during which waste materials are combusted in an industrial furnace under controlled conditions.[129] It can be applied to both VFG and sludge. Generally, this is not a preferred treatment due to its relatively low position in the EU waste hierarchy. Potentially, some of VFG waste that is incinerated could be used instead for recovery.

In Croatia, the estimated amounts of produced VFG from municipal waste, on average, constitute around 489.404 tonnes.[130] As mentioned before, around 11% of total produced bio-waste is separately collected, of which 20% (95.471 t) is directed to recovery (composting, anaerobic digestion).[131] The data on how much waste from VFG fraction is directed to specific types of reprocessing methods is sparse. However, we do know that in 2017, 37,626 tonnes of bio-waste was composted, in nine composting facilities (HR: kompostane).[132] The largest portion of composted waste came from municipal waste, specifically from the fraction 'waste from garden and parks', which made up 78% of composted waste. Bio-waste from kitchens and cantinas made up only 14% of composted waste.[133] Croatia's total composting capacity in 2017 was 107,689 tonnes, while the actual amount of biodegradable waste composted was 39,389 tonnes – meaning that only 37% of the available composting capacity was used.[134] We also know that 46,546 tonnes of bio-waste were reprocessed using anaerobic digestion (mainly into biogas), and that 99% of this bio-waste came from manufacturing industries, while only a portion of the remaining 1% came from municipal bio-waste from kitchens and cantinas.[135]

Croatian policy plans relevant to reuse of bio-waste find that reprocessing and recovery operations are 'more suitable for homogeneous, commercial waste streams such as agricultural residues and waste from the food industry, while they are less suitable for municipal bio-waste'.[136] They claim that 'food waste generated in the processing phase, which is characterised by homogeneity, has a great potential for obtaining high-value products, as opposed to food waste generated in the consumption phase, which is characterised by high heterogeneity'.[137] Although this reasoning is not supported universally, it certainly explains why some countries, such as Croatia, place an emphasis on collection and reprocessing of industry bio-waste, as opposed to household bio-waste.

[129] 'Incineration – waste management' (2020) Encyclopaedia Britannica.

[130] Ministarstvo gospodarstva i održivog razvoja, 'Izvješće o komunalnom otpadu za 2022. Godinu' (July 2023) [Report on municipal waste for the year 2022]; Government of the Republic of Croatia (2017) 18.

[131] Ibid.

[132] Croatian Agency for the Environment and Nature (2018) 26.

[133] Ibid.

[134] Croatian Agency for the Environment and Nature (2018) 27.

[135] Croatian Agency for the Environment and Nature (2018) 31.

[136] Croatian Agency for the Environment and Nature (2018) 20.

[137] Ibid.

Caution Around Reprocessing of VFG

VFG is often perceived as a cheap, renewable resource – which is partially true but partially misleading. Management of VFG *does* contribute to the effective management of organic municipal solid waste and aerobic/anaerobic biotechnological processes are relatively cheap and economically feasible.[138] Furthermore, VFG is technically renewable because vegetables and fruits have a biogenic origin. However, a lot of non-renewable resources (energy and fertiliser to start) are applied in the production, processing and transport of vegetables and fruit, meaning that their overall production is neither entirely sustainable, nor are they an entirely renewable resource.[139] Instead, studies point to VFG as an environmental burden that needs to be treated with the lowest possible environmental impact in a way that allows recovery of the parts of these resources that were initially used in food production, processing, transport or as food itself.[140] This is why the products (organic matter containing sugars, fatty acids, amino acids and nutrients including nitrogen and phosphorus) and energy obtained after treatment of VFG should be reused. To create a circular system, nutrients and organic matter can be used for compost/soil conditioners or as energy in the form of fuel – or both.[141] The net environmental benefit of VFG treatment must reflect the resources and energy consumed in the collection and movement of the waste from production source to treatment location.[142] In this way the renewable and non-renewable resources invested in the production of fruit and vegetables can be returned into the agricultural cycle via the reprocessing of VFG. In this way, the open loops are closed as nutrients and returned to farms, soil is regenerated and the reliance on artificial fertilisers is reduced.[143] As such, the reprocessing of VFG contributes to the 'recycle' and 'recover' steps of the waste hierarchy.

An article by Pleissner in 2018, also pointed to a risk associated with the recycling of food waste, that is, the obtainable products have a higher economic value than the initial foodstuff. For economic reasons, more material that could be food might end up as feedstock in bio refineries.[144] To conclude, and in generally, in order to reach the sustainable development goals[145] and the goal to reach zero hunger, food should be used as food as much as possible.[146] This is

138 Pleissner (2018), 39.

139 Ibid.

140 Ibid.

141 Ibid.

142 Environmental Services Association (2014) 8.

143 Nick Jeffries, 'A circular economy for food: 5 case studies' (2018).

144 Pleissner (2018), 40.

145 The target to reduce food waste fits with Goal 12 of the United Nations 2030 Agenda for Sustainable Development, to Ensure Sustainable Consumption and Production Patterns. This includes a commitment to halve per capita global food waste; Oakdene et. Al. (2017) 28.

146 Pleissner (2018), 40.

in line with the EU waste hierarchy, according to which prevention is the most desirable approach.

2.4.2 Treatment of Sludge

Some treatment routes and considerations are specific to each waste stream; for sludge, these are discussed here. Globally, the most frequent methods for disposal of sludge are incineration, landfilling and ocean-dumping, but treatment and recycling are becoming more frequent. Following treatment, the material streams can be used in agriculture as soil amendments or the ashes from sludge incineration can be used in the production of cement, bricks and asphalt.[147]

'Dumping' or landfilling is the least preferred method for getting rid of waste in the EU because of the negative environmental implications that come with dumping untreated sewage sludge and other materials into the Earth.[148] Incineration is the second-most-preferred method of sludge disposal (and is increasing), with 29.5% of total sludge collected in the EU being incinerated.[149] Incineration is a method by which waste is combusted – resulting in energy and incineration ashes.[150] Incineration is interesting because while energy recovery (its main product) is lower down in the waste hierarchy than recovery of other materials (such as nutrients), incineration is in some cases a necessary step in the process of nutrient recovery. For example, incineration is a prerequisite for the recovery of P from ashes. Therefore, the aim of waste legislation should not be to completely eliminate incineration as a treatment process.

Incineration use has increased in many European Member States, due to the 'large volume reduction in sludge and thermal efficiency' of the process.[151] Incineration of sewage sludge can be done in a mono-incineration or a co-incineration plant. In co-incineration plants, sewage sludge can be used as a regular or additional fuel, while in mono-incineration plants, sewage sludge is the only fuel. In order to be used as a fuel the sewage sludge is dried and, via incineration, can be converted into energy.[152] This distinction between mono- and co-incineration plants might prove to be important for the public and market acceptance of nutrients extracted from ashes because with co-incineration different waste streams may be co-incinerated and this may be hampering use of the recovered material streams.

147 Gherghel (2019) 248.

148 High impacts are related to the leachate production and CO2 equivalent emissions (Kacprzak et al., 2017); Gherghel (2019) 248.

149 Đurđević, Blecich and Jurić (2019), 4.

150 Eurostata, 'Glossary: Incineration' (Eurostat Glossary, February 2013).

151 Gherghel (2019) 248; P. Manara & A. Zabaniotou. 'Towards sewage sludge based biofuels via thermochemical conversion–a review.' Renewable and Sustainable Energy Reviews 16.5 (2012) 2567.

152 Đurđević, Blecich and Jurić (2019), 2.

Another relevant method of sludge disposal/treatment is long-term storage, which is more of a novel idea. It refers to the storage of resources and materials for which there are currently no financially and/or technically feasible recycling options, but for which some feasible recycling options are expected in the near future (a decade or so).[153] Long-term storage of sewage sludge has a disinfecting property, meaning that it can reduce the amount of viruses and bacteria in sludge.[154] Furthermore, studies have found that in the right conditions, and with the right collection intervals, long-term storage is possible without harming the valuable matter content in sewage sludge.[155] Despite this, the practice of long-term storage is not widely applied, with the average storage duration in EU Member States being approximately six months.[156]

Finally, when sludge is recycled 42.7% of total sludge collected in the EU is reused in agriculture.[157] In accordance with the Sewage Sludge Directive (86/278/EEC), reuse of sewage sludge in agriculture is allowed only for treated and stabilised sludge, with certain limits on concentration on heavy metals and organic pollutants.[158] Despite these standards at the EU level, the recycling of sludge to agriculture is very different among Member States.[159] These differences are in part due to population density and land availability, but they also have to do with the perception of sludge as a potentially dangerous matter to be spread across agricultural soil.

There is a group of chemical treatments, of a relatively high technological readiness level (herein: TRL), which apply to sludge more so than to VFG: Chemical Precipitation/Crystallisation. Chemical precipitation is a container term for several processes, in which soluble nutrients are precipitated as solids and separated by settling.[160] Aluminium or iron-based coagulants are commonly used for accumulating P from dilute wastewater, with the main products of the process being Fe or Al P salts.[161] This means that this process is currently only relevant for phosphorus. Crystallisation is a process that falls under this container term. It is used to recover phosphorus from WWTPs, in the form of struvite or other salts.[162] Struvite can be recovered from the reject water following anaerobic digestion and solid liquid separation of the sewage sludge. The

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153 M.L. de Betrancourt, 'NV Slibverwerking Noord-Brabant' (SNB Presentation downloaded from RWS website, 2017).

154 European Commission DG Environment, 'Disposal and recycling routes for sewage sludge', 43.

155 E. Johannessen, A.S. Eikum and T. Krogstad. 'Long term in-line sludge storage in wastewater treatment plants: the potential for phosphorus release.' Environmental technology 33.24 (2012): 2723-2731.

156 European Commission DG Environment, 'Disposal and recycling routes for sewage sludge', 47.

157 Đurđević, Blecich and Jurić (2019), 4.

158 Đurđević, Blecich and Jurić (2019), 7.

159 Gendebien (2010) 2.

160 Mehta (2015) 4938; Ahmed, Mukhtar, et al. 'Innovative Processes and Technologies for Nutrient Recovery from Wastes: A Comprehensive Review.' *Sustainability* 11.18 (2019): 4938.

161 This is only relevant for sludge, because the precipiates may end up in the sludge; Mehta (2015) 4938.

162 Gherghel (2019) 251.

benefits of struvite 'are considerable for the production of a slow-releasing fertiliser', for 'use as a base material in the phosphate industry for making fire-resistant panels, and as a binder material in cements'.[163] Nowadays, there are a several such processes commercially available.[164]

According to Gendebien et al., 'population density and the availability of agricultural lands for sludge recycling to land will continue to be an important factor influencing policy decisions on sludge management'.[165] If Member States do not have a lot of agricultural land on which to apply the produced sewage sludge, then naturally it is harder to find an incentive to properly collect, treat and use sewage sludge. Nevertheless, even if there is enough agricultural land, there also needs to be a high level of acceptance by farmers and the public.

The Netherlands is the EU Member State that has the smallest 'utilisable area' compared to its amount of sludge production, and it is also one of the Member States with the most stringent standards regarding sewage sludge, which has 'resulted in an effective ban on use of sludge for agriculture'.[166] As such, the vast majority of sewage sludge in the Netherlands is incinerated. As can be seen in Table 2 below, in 2020 the Netherlands produced 353.85 thousand tonnes of sewage sludge, of which the majority is disposed of via incineration. Only 1.10 thousand tonnes are disposed of via landfill and 4.18 via the creation of compost and 'other uses'.[167] None of the sewage sludge was disposed of through use in agriculture.[168]

	Production (Total)	Disposal (Total)	Landfill	Agriculture	Compost or 'other'
Netherlands	353.85	308.36	1.48	0	4.18
Croatia	22.51	5.92	0.71	0.48	0.82

Table 2: Showing the amount of sewage sludge (in thousand tonnes of dry mass) collected and disposed of via four relevant disposal routes, in the Netherlands and Croatia during 2020[169]

Over the last 15 years in Croatia, there has been quite some fluctuation in the legislation applicable to sewage sludge, leading to varying numbers of sludge collection and disposal over the years. From 2009 to 2011, only biologically-treated food industry wastewater sludge was used in agriculture and as a soil

[163] Gherghel (2019) 252.

[164] Ibid.

[165] Gendebien (2010) 4.

[166] Gendebien (2010) 4.

[167] Eurostat (2022).

[168] Ibid.

[169] Ibid.

improver on green areas. From 2012, sludge from purified municipal wastewater was also used in agriculture. As a result, an 80% increase in the use of sludge in agriculture was reported in 2018 (compared to 2012). However, in 2019 and 2020, 64% less unprocessed sewage sludge was sent to agriculture and as soil improver in green areas.[170] The reason for the decrease is the entry into force of the Ordinance on the Protection of Agricultural Land from pollution (71/19) in June 2019, which no longer allowed the use of unprocessed sludge on agricultural land used for food production

In 2020, Croatia produced 22.51 thousand tonnes of sewage sludge, of which 0.87 thousand tonnes were used in agriculture, 7.28 were disposed of via landfill and 0.26 thousand tonnes were made into compost or used in other applications.[171] For incineration we only have the numbers for 2019, when 0.04 thousand tonnes were incinerated, because Croatia has no incineration plants of its own and is forced to rely on neighbouring countries like Italy and Austria.

2.5 Products Made from VFG and Sludge Recovered Materials

If we look back to the figure of VFG and sludge materials 'life cycle' on page 4 of the present chapter, we can see that from the label 'Food Production' that the circle loops around and back into 'Food Production', 'Non-Fertiliser Production' and 'Energy Production'.[172] This part of the life cycle is important because it distinguishes between the different product outputs of VFG and sludge treatment. As explained in a study by Lohri, 'sustainable waste recycling requires a supply of adequate waste materials as input, and a market demand for the output products'.[173] The life cycle of the input waste materials was discussed above, and the resulting output products can be used (in the case of VFG) in agriculture, bio-energy and various platform chemicals.

First, in agriculture, nutrients and other organic matter from reprocessed waste can be used in a variety of different fertiliser products: Compost, Organic fertiliser, Organo-mineral fertiliser, Inorganic fertiliser, Soil improver, Growing medium, Inhibitor, Plant biostimulant and Fertilising product blend. The recovery methods for micronutrients are still largely in the testing phases, but this is an area where the law could provide a future outlook, moving ahead of the science. This future-oriented approach is also important for recovery of essential metals, such as zinc, which are in short supply. It is predicted that after 2050,

[170] Hrvatska Agencija za Okoliš i Prirodu (Croatian Agency for the Environment and Nature), 'Review of data on sludge management from waste water treatment [Pregled podataka o gospodarenju muljem iz uređaja za pročišćavanje otpadnih voda]' (Agency Report, July 2020), 3. The Croatian Agency for Environment and Nature is no longer active after a recent restructuring; however, their reports and findings remain relevant.

[171] Eurostat (10 August 2022).

[172] See the introduction to the General and Bio-technological Chapter (Chapter 2).

[173] Lohri (2017) 84.

zinc's stock-in-society will be larger than known extractable reserves.[174] This means that recovery from all possible in-society stocks (including from sludge) will be increasingly more attractive and important.[175] This is the case not only for zinc, but also other materials like mineral vivianite, iron phosphate, which new research also suggests can be recovered from sludge.[176]

Second, reprocessed VFG and sludge can be used in the production of bio-energy. Conversation of waste streams into energy, in this case bio-energy, is the least preferred method in both the waste hierarchy of the EU and the bio-based value pyramid schemes. However, the world's 'dwindling petroleum reserves raise the interest for technologies to convert (and upgrade) bio-waste-derived products into transportation fuels'.[177] As such, although it is not the main focus of the present research, the possibility to covert VFG and sludge into bio-energy should be kept in mind. Both waste streams can be converted into bio-oil and biogas, and these products can then be used as fuel for various processes, but particularly interesting for the circular economy: to power waste plants and treatment facilities.[178] Using the products of reprocessing to power the reprocessing itself would create feedback loops between the energy produced from waste treatment and the energy needed to keep the whole system functioning. It should also not be forgotten that incineration of sludge, paired with recovery from the ashes, results in recovery of both energy and phosphorus (and in the future possibly other nutrients). However, it is unavoidable that almost all carbon, which is also a useful organic matter that can replenish shortages in agricultural soils, will be destroyed in the process.

A final product that can be produced through the reprocessing of VFG and sludge are platform chemicals. Platform chemicals are chemical building blocks which can be converted into a wide range of materials.[179] Synthetic materials consist of polymers, and those polymers consist of various monomers, some of which may be converted into the same platform chemicals.[180] At present, most synthetic materials are made from petroleum polymers.[181] However, more circular alternatives exist. One example are bio-plastic poly-

[174] H.U. Sverdrup, A.H. Olafsdottir & K.V. Ragnarsdottir (2019). On the long-term sustainability of copper, zinc and lead supply, using a system dynamics model. Resources, Conservation & Recycling: X, 4, 100007.

[175] H. Yesil, R. Molaey, B. Calli. & A.E. Tugtas, 'Removal and recovery of heavy metals from sewage sludge via three-stage integrated process' (2021) Chemosphere, 280, 130650.

[176] 'Many waterboards dose iron salts to be able to remove phosphate from the waste water. Until recently, it was thought that the iron phosphate that is formed cannot be recovered, but new research by Wetsus using a magnetic separation technique from mining shows that this is possible', Energie en Grondstoffen Fabriek, 'Fosfaat (Phosphate)' (EFGF Website, 2020a) .

[177] Lohri (2017) 85.

[178] Environmental Services Association (2014) 8.

[179] Ingrid Van der Meer, 'Plants as producers of platform chemicals' (Wageningen University Biobased Economy blog, March 2016).

[180] Van der Meer (2016).

[181] Ibid.

mers, such as Polyhydroxyalkanoates (herein: PHAs). PHAs are produced through a series of bio-conversion processes in which food waste is converted into volatile fatty acids and stored at the microbial cell level.[182] In this way, renewable materials from waste streams can ultimately, through a series of microbial and chemical reactions, be transformed into PHA-based bioplastics, which then have a variety of applications in medicine, agriculture and as compostable plastics.[183] Bioplastics can also be used to make, for example, biodegradable 'casings' for fertiliser granules (which facilitates the release of the fertiliser in a timely and targeted manner to various crops, with less loses to air and water; but also do not contribute to the accumulation of micro-plastics in our environment).[184] Other applications include biodegradable nets and bags, alternatives to fishing lead and the creation of construction materials, such as artificial lightweight aggregates (ALWA), slag, bricks and glass.[185]

Furthermore, new recovery product applications are continually being discovered, such as 'Kaumera Gum', a raw material that can be obtained from both residual waste and wastewater.[186] Kaumera can 'repel and absorb water, is an excellent binder and is fire-resistant'.[187] When Kaumera is made from purified sludge, less sludge has to be removed and destroyed, making the practice favourable because it both reduces energy consumption and CO2 emissions.[188]

In Sum

The aim of describing the full life cycle of the materials that end up in VFG and sludge streams was to illustrate the way that the different stages of the life cycle are interconnected and feed into each other. The most important examples of this interconnectedness are:

- The connection between raw materials (N, P, K) and agricultural production. This section highlighted that the goals of minimal external input and closing nutrient loops are closely related. Nutrient loops can be closed by recycling nutrients from the waste streams and using them in agricultural production (as fertilisers and other types of soil amendments), which at the same time reduce the amount of external inputs to the agricultural process in the form of chemical fertilisers that are dependent on non-renewable raw materials from the Earth.
- The connection between the way VFG and sludge materials are produced,

[182] Russo et al (2019) 967.

[183] Ibid.; Wojnowska-Baryła and others (2020) 2088.

[184] Della Pietra (2019) 13; Energie en Grondstoffen Fabriek, 'Bioplastics' (EFGF Website, 2023a).

[185] Energie en Grondstoffen Fabriek (2023a); Gherghel (2019) 154.

[186] Energie en Grondstoffen Fabriek 'Kaumera' (EFGF Website, 2023b); The Raw Materials Factory in Zutphen was opened in October 2019. This is the first location in the world where Kaumera is produced. A second location in Epe will be opened at the end of 2020. In Zutphen, Kaumera is made from residual water from Friesland Campina's dairies.

[187] Energie en Grondstoffen Fabriek (2023b).

[188] Ibid.

the way each is collected as waste and the eventual products that can be made from materials recovered from treatment.

Another key aspect of the life cycle of these materials that this general section sought to highlight is the importance of careful use and minimisation of food waste, prior to seeking treatment and reprocessing. Reuse prior to the materials being discarded and becoming waste is the more responsible approach, because the intended function of the product is kept and because energy and resource use associated with treatment and transport of the materials is avoided entirely.[189] This underlines that while treatment and recovery are better waste treatment options than landfilling, the net environmental benefit of treatment must reflect the resources and energy consumed in the production, collection, transporting and treatment.[190]

Finally, despite the fact that there are major differences between the Netherlands and Croatia, both could reap many of the same benefits if they sought to focus their economies on the reuse and recovery of VFG and sludge materials.

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189 Pleissner (2018), 39.

190 Jeffries (2018).

CHAPTER 3

Legal Basis for EU Action Relevant to the VFG and Sludge Material Streams

One of the aims of the present research is to explore the degree to which tensions around national and EU competence affect circularity transitions relevant to the VFG and sludge waste streams. It may seem obvious that the European Union takes action on matters relevant to the environment and the single market, however there are still concerns when it comes to division of competences in this area. When assessing existing legislation and possible future legislation, it is necessary to first examine the constitutional settlement based on the principles of conferred powers, subsidiarity and proportionality, that impacts circularity transitions regarding VFG and sludge. That examination is the primary purpose of this chapter (sections 3.1, 3.2 and 3.3), alongside the application of the competence settlement to existing legislation in section 3.4.

Academic literature relevant to conferral, subsidiarity and proportionality in the EU has highlighted that despite a 'thick constitutional framework' around the division of authority between EU and member state institutions, uncertainties still remain as to how authority can best be divided.[1] These uncertainties come about as a result of 'the balancing of unity and diversity; adverse effects of national implementation choices and an oftentimes far from straightforward and consistent approach by the CJEU'.[2]

Relevant to the present research, these uncertainties are particularly evident around complex issues such as waste and the materials contained therein.[3] Waste can be seen as a complex issue because of the paradox that exists around it, in that waste management issues have global consequences, but are performed very locally in the day-to-day. The global aspect comes from the transboundary effects of improper waste disposal for the environment and public health, and in this instance also the shared concern (both economic and environmental) over the long-term availability of non-renewable nutrients in discarded waste material.[4] This paradox is present at the international level, but it trickles down to the regional level as well, where (in the case of the European Union) questions arise around EU and Member States competence over such a global-local issue.[5]

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1 R. Lopatka, 'Subsidiarity: Bridging the gap between the ideal and reality.' European View 18, no. 1 (2019) 27; T. van den Brink and V. Passalacqua, 'Balancing Unity and Diversity in Composite Legislative Frameworks' in Ton van den Brink and Virginia Passalacqua (eds.) Balancing Unity and Diversity in EU Legislation (Edward Elgar Publishing, 2023); R. Schütze, 'From Dual to Cooperative Federalism: The Changing Structure of European Law' (2009) 5; S. de Vries, E. Loriatti, P. Guarda, and F. Guella. 'The categorization of economic rights' (2015): 1-407.

2 Van den Brink & Passalacqua (2023) 1.

3 F. Jacobs, The Role of the European Court of Justice in the Protection of the Environment' Journal of Environmental Law, 2006, 18(2), 195.

4 See sub-section 1.1, 1.2 and 1.3 of the Introduction Chapter (Chapter 1) for a better understanding of these shared concerns over the long-term availability of these non-renewable nutrients, particularly those that are essential to our agricultural systems.

5 For the international level see: D. Bodansky, 'The legitimacy of international governance: a coming challenge for international environmental law?', American Journal of International Law 93, no. 3

3.1 Legal Basis

Under the principle of conferral, the EU has the power to act within the limits of the competences conferred upon it by Member States to attain the objectives set out in the founding treaties.[6] The legal basis for these actions are many and the EU's contemporary constitution 'contains an especially refined system of provisions regulating the competence for the legislature to act: a catalogue of competences, a very elaborate list of legal bases; the subsidiarity and proportionality principles as well as all kinds of substantive norms that EU legislature needs to respect and further implement'.[7]

The legal basis for EU action in VFG and sludge management comes either from environmental (Article 191 and 192) or internal market (Article 114) provisions of the TFEU. Despite the existence of these legal basis, Krämer still considers that a consistent EU waste management policy has not been developed, 'because it is not clear to what extent waste management strategies, policies and measures are to be established at the EU or at the national level.'[8]

Legal bases define 'the objectives legislation should pursue; thereby both giving direction to EU action and defining the extent to which the EU can act.[9] Article 191 finds that Union policy on the environment 'shall contribute, among other things, to protecting and improving the quality of the environment, protecting human health, ensuring prudent and rational utilisation of natural resources, and combating climate change'.[10] Particularly relevant for the present chapter and the circular economy overall is 'ensuring of prudent and rational utilisation of natural resources', because natural resources cover the management of *all* resources found in the environment.[11] This can be interpreted to include the conservation of raw materials in the Earth, including by methods such as the recovery of materials from waste. This broad interpretation of the environment gives EU environmental law an extensive scope and provides a legal basis for the circular economy transition.[12]

(1999): 598; For the EU level see: L. Krämer, 'EU environmental law.' Environmental liability 4 (2012) and; E. Chioatto and P. Sospiro, 'Transition from waste management to circular economy: the European Union roadmap', Environment, Development and Sustainability 25, no. 1 (2023): 249-276.

6 The catalogue of competences (Arts 2–6 TFEU) distinguishes between types of powers; T. van den Brink, 'The impact of EU legislation on national legal systems: Towards a new approach to EU–member state relations', Cambridge Yearbook of European Legal Studies 19 (2017): 216.

7 Van den Brink & Passalacqua (2023) 1.

8 Krämer (2012) 333 (10-07).

9 Van den Brink & Passalacqua (2023) 3.

10 Consolidated version of the Treaty on the Functioning of the European Union [2012] OJ C 326/12, Art 114 and 191.

11 de Romph, T., 'The legal transition towards a Circular Economy–EU environmental law examined' (Doctoral Thesis, KU Leuven, 2018), p 16; Krämer (2012) 10-18 and; Chioatto and Sospiro (2023) 5.

12 Krämer (2012) 4.

Article 114, on the other hand, is the broadly applied general harmonization provision for the establishment and functioning of the internal market. The article applies to the VFG and sludge materials only after the treatment phase of their lifecycle, when the recovered materials are made into products that can be traded on the internal market.[13] Products require uniform rules not to hinder their free movement, while also pursuing a high level of environmental protection that takes into account any new scientific developments. This is called for by Article 114(3), which states that the Commission takes environmental protection and human health into account while seeking to achieve the internal market objectives. It is not necessarily a problem, but it is interesting that an internal market justification can be widely used in a matter like this, where an environmental legal basis would seem more appropriate.

Relevant to this, Van den Brink and Passalacqua highlight how Article 114 has become a platform 'for the balancing and achievement of economic, but especially also of a broad range of non-economic public interests'.[14] They build on the explanation from De Vries in 2015 that explains how 'the Treaties concern not only the establishment, but also the well-functioning of the internal market. Legislation thus becomes key, as it provides the only appropriate way for balancing public interests, especially when these are in conflict'.[15] From these explanations we can see that the extent to which powers can be conferred to the EU in this arena is very much subject to legislative choices, rather than court scrutiny (which is very limited on this topic). For example, it was a legislative choice that the Green Deal legislative proposals were largely adopted on the basis of 114 TFEU 'even though their primary objective is environmental protection and the internal market objectives are less central or even peripheral'.[16]

Union competence in waste management further derives from two key Union obligations that have been developing and deepening since the first Single European Act in 1987.[17] These obligations are: balancing the requirements of market integration with those of environmental protection; and the enforcement of community environmental policy.[18] Both involve complex political and economic considerations, in which Union legislation typically

[13] TFEU, Article 38(2), Article 39, Article 44; de Romph (2018) 18.

[14] Van den Brink & Passalacqua (2023) 3-4.

[15] Ibid.; de Vries, Loriatti, Guarda, and Guella (2015) 1-407.

[16] Van den Brink & Passalacqua (2023) 5.

[17] Jacobs (2006) 195.

[18] Case C-2/90 (Walloon Waste) Commission of the European Communities v Kingdom of Belgium [1992] ECLI 310; Case C-28/09 European Commission v Republic of Austria Belgium [1992] ECLI 854; Case 302/86 (Danish Bottles) Commission of the European Communities v Kingdom of Denmark [1988] ECLI 421; Case 240/83 (ADBHU) Procureur de la République v Association de défense des brûleurs d'huiles usagées (ADBHU) [1985] ECLI 51. The *Walloon Waste* case, decided in July 1992 (confirmed that waste it to be regarded as a 'good'). *Commission v Austria*, conformed that accumulation of waste constitutes a danger to the environment. *Danish Bottles* and *ADBHU* cases confirmed that 'the protection of the environment constitutes one of the Community's essential objectives and that it also constitutes one

holds a wide margin of discretion, even outside the fields of waste and environmental law.[19] The environmental objectives at the core of these articles give the EU competence to act in each of the phases of the VFG and sludge lifecycles (conservation, collection, treatment and products) as long as the actions are proportional. On the topic of waste, it remains a contested issue whether this wide margin of discretion is warranted and valuable in resolving issues that are largely national, even local, in nature. The following two sections discuss the degree to which the subsidiarity and proportionality mechanisms can aid the balancing of EU and national competence relevant to these obligations in the management of VFG and sludge.

The legal basis discussion is important in itself, but it is also important because the subsidiarity assessment that follows is dependent on the type of legal basis chosen. If the internal market legal basis is chosen, then the subsidiarity assessment is simpler. Seeing as the objective is EU-wide (that products recovered from waste have access to the broader EU internal market) then it is difficult to see how Member States could be better placed to regulate this area than the EU itself. Conferral of power to the EU is almost automatic under the internal market objective.

However, when the environmental legal basis is chosen the subsidiarity assessment becomes significantly more complex, and it is not always clear whether the EU or Member States are better suited to achieve the relevant environmental and waste objectives. For example, in the case of the VFG and sludge waste streams it is difficult to use the environmental to justify EU interference in the frequency of collection for specific waste streams or the spatial planning of WWTPs to be in alignment with circularity objectives. In these instances (as we will see) Member States argue that the local-nature of these matters Member States can better achieve environmental and waste objectives by regulating this themselves.

Despite this, there is increasing pressure at the EU level to increase and improve circular waste collection and treatment. For example, Article 11(1) of the WFD sets the requirements for European Member States to promote high-quality recycling through their waste collection systems. Article 11(2.c) makes this more concrete, by setting a target for a 55% increase of recycling and preparation for re-use on municipal waste by 2025. Such EU-wide targets and regulations with a purely environmental legal basis require a lengthier subsidiarity consideration.

of the acceptable 'mandatory requirements' which national authorities could rely on to restrict the entry of goods from other Member States'; Francis (2006) 189.

19 Jacobs (2006) 195.

3.2 Subsidiarity

The subsidiarity principle has been specifically designed as a mechanism to balance EU and national competence.[20] Regarding subsidiarity, the TFEU's Article 5(3) justifies action at the EU level 'if the objective of the proposed action cannot be sufficiently achieved by the Member States either at central level or at regional and local level, but can rather...be better achieved at Union level'.[21] While action at the EU level is typically considered to increase efficiency, this comes at the risk of creating democratic voids and lacking broad support.[22] Subsidiarity therefore attempts to ensure that EU action is in line with the EU's democratic principles, and that decisions are taken as closely as possible to the citizen.[23] This gives rise to subsidiarity tensions between the assumed efficient action at the EU level, and the potentially less-efficient but more democratic action at the national and regional levels.[24]

The contours of subsidiarity are still not an entirely unsettled subject in academic and judicial debate. Van den Brink and Passalacqua have argued that a less technocratic and more political approach to subsidiarity would be broader and 'more closely linked to the conferral and proportionality principles as well as to the respect for national constitutional identities'.[25] As Schütze argued, the subsidiarity principle should not be interpreted too narrowly and 'should take account of the actual content of the proposed legislative measure'. A broad notion to subsidiarity means Member States have more leeway to make legislative choices different to those at the EU level, which is important in highly technical legislative areas where there appears to be no one-size-fits-all solution.

As with most environmental protection matters, this involvement of the EU level is legitimized by the legal basis in Article 191 of the TFEU, and the transboundary effects of environmental over-use and resource conservation.[26] However, we also see that implementation of EU waste legislation at the Member-State level has remained patchy.[27] Additionally, some possible community action, like the creation of a supra-waste inspection authority has been

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[20] P. Craig, 'Subsidiarity: A political and legal analysis.' JCMS: Journal of Common Market Studies 50 (2012): 72-87.

[21] Consolidated version of the Treaty on the Functioning of the European Union [2012] OJ C 326/12, Art 5(3).

[22] I. Wanzenböck & K. Frenken, 'The subsidiarity principle in innovation policy for societal challenges, Global Transitions' (2020) 55 et seq.

[23] Consolidated Version of the Treaty on European Union [2008] OJ C115/13, Article 10(3).

[24] Ibid.

[25] Van den Brink & Passalacqua (2023) 7.

[26] Jacobs (2006) 195.

[27] Austrian Federal Council, Reasoned Opinion COM/2014/397, 18/09/2014; Total waste generation is increasing (and varies extremely between member states). Additionally, treatment methods used vary (making it difficult to track if targets are being met); Jackson and Watkins (2012), 3.

unpopular with Member States.[28] Both of these confirm a lack of wide support for Union action in this area. The possible benefits of Member States taking the lead in legislating this area are discussed below through their reasoned opinions on topics relevant to waste.

3.2.1 Member States Reasoned Opinions on Subsidiarity

As described above, a lot of discretion around topics of waste and the environment is left to legislative practice at the member state level. This is why it is relevant to look at the reasoned opinions of member states on these topics, to better understand their justification in calling for more or less EU action.

All the reasoned opinions relevant to VFG and sludge waste were reviewed to indicate the types of subsidiarity arguments brought up by Member States. Austria, for example, in its 2014 reasoned opinion on the WFD, made the argument that the EU should focus on helping Member States comply with existing substantive norms, rather than continually developing new ones.[29] Austria argued (by virtue of the subsidiarity principle) that for the Member States currently failing to meet waste targets, the reasons for failing are entirely regional, and should thereby be resolved by the countries concerned rather than the EU as a whole. Austria suggests that the way the EU could play a role is by doing more to monitor compliance with existing targets, as setting new targets is futile before all Member States have achieved existing targets.

Austria's argument is based in market integration thinking, as it suggests that 'disparities in waste management are preventing fair competition among the Member States' and that the gap will continue to grow wider if targets continue to be raised.[30] While these are definitely important points for the EU to consider, especially when it comes to doing more to assist Member States in meeting existing targets, the counter argument to Austria's point is that the EU is striving to push those who can do more to do more. It can be argued that this is in line with subsidiarity because, considering the time-sensitive nature of the environmental problems at hand, these objectives can be better achieved at the Union level. Furthermore, the perspective embodied in Austria's argumentation neglects a key part of subsidiarity, which intends for the EU to anticipate implementation challenges at the national level.[31] A recent ruling by the Court of Justice against Estonia, has also deemed that these types of individual circumstances do not necessarily result in a negative subsidiarity assessment.[32] The court found that the individual circumstances cannot be obstacles to EU

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[28] Jackson and Watkins (2012), 3.

[29] Ibid.

[30] Austrian Federal Council, Reasoned Opinion COM/2014/397, 18/09/2014.

[31] Van den Brink & Passalacqua (2023) 8.

[32] Case C-508/13 Republic of Estonia v European Parliament and Council of the European Union [2015] ECLI 403; M. Huysmans, T. van den Brink, and P. van Gruisen, 'Subsidiarity Ex Ante and Ex Post: From the

regulation because while some Member States may have circumstances requiring less EU action, other Member States might have situations that do require EU regulation to resolve. As such, individual circumstances must be heavily qualified if they are to be deemed a barrier to EU action.

A different argument about target setting was brought up in two reasoned opinions from 2014: one from Czech Republic on the circular economy package and one from Croatia on a series of amendments to EU waste legislation. The Czech Republic found the draft circular economy package directives to be in conflict with subsidiarity because the Commission had not 'substantiated that the proposed targets are realistically attainable at reasonable costs for the Member States and municipalities, and therefore the Commission has not justified the real added value of the proposed action at EU level'.[33] Furthermore, the Czech Republic deemed the proposed objectives to not be realistically attainable given the time schedule, especially in comparison to the economic burdens associated with fulfilling the targets. They further noted that the proposed changes affect the 'competence of municipalities and may interfere in their long-term investments as well as in the functioning of the sorted waste collection system'.[34]

This reasoning was echoed in the Croatian reasoned opinion which found that further setting of more ambitious targets based in the environmental objectives of TFEU Article 191, without a differentiated and flexible approach, will generate additional disparities between the Member States as regards economic and social development, which is contrary to the Union's objectives.[35] The reasoned opinion goes on to highlight how some Member States, including Croatia, have a specific position in view of the transition period provided by the Accession Treaty in regard to implementation of the *acquis* in the waste management sector. As such, Croatia called for the Union to bear in mind the situational, economic, but also the geographic differences between Member States when setting additional targets in the field of waste management.[36]

A further French reasoned opinion from 2016 of the Landfill directive called into question the use of recycling costs as a justification of normative Union intervention in member state waste disposal practices.[37] As well as the establishment of EU definitions for the terms 'recovery' and 'disposal' (which are commonplace in EU law today), on the grounds that such definitions set at the EU level could compromise national practices which are by nature more capable of taking into account the technical, economic and environmental

Early Warning System to the Court of Justice of the European Union', (2023) JCMS: Journal of Common Market Studies.

33 Parliament of the Czech Republic Senate 9th Term Committee on EU Affairs, 324th Resolution, Reasoned Opinion (30th September 2014).

34 Ibid.

35 Croatian Parliament, Reasoned Opinion COM/2014/397, 06/10/2014.

36 Ibid.

37 French Senate, Reasoned Opinion Resolution No. 78 (2015-2016), 02/02/2016.

considerations. Finally, France took issue with the Early Warning Report process, triggered in the event that a member state failed to achieve pursued objectives. France called for more clarity in the draft directives on the binding nature of recommendations in the Early Warning Reports.[38]

At their core, all these arguments boil down to a request that the impact of measures on individual Member States be better analysed, taking into considerations their unique economic circumstances and their ability to fulfil the given targets and meet the set objectives (without harming their national waste management systems). These concerns from member states are important and a balanced and delicate approach to subsidiarity is needed. The EU institutions have recognized that change is needed faster, but they should develop ways to better aid Member States in achieving compliance with existing targets and objectives within a broad approach to subsidiarity – that is more democratic and closer to citizens.

However, existing policy, especially targets that guide transitions, should be amended to minimize member state action that runs counter to the overarching objectives. For instance, the 1999 Landfill directive includes a target to reduce the maximum landfilling rate for recyclable waste (including bio-waste) to 25% by 2025. Coupled with the increased recycling targets, it is hoped that the reduced landfilling target will improve re-processing practices EU-wide. However, while the landfilling targets are largely successful in diverting waste from landfills, they do leave room for Member States to be in compliance while still incinerating a majority of their waste (contrary to the waste hierarchy). Professor Krämer in 2012 already noted that this would be the case if waste management policies found their legal basis only in the environmental articles of the TFEU. He commented that since article 192 does not contain conditions which needs to be 'authorised' (as is the case with article 114), conditions adopted on its basis would be of 'a relatively low common denominator'.[39]

If subsidiarity remains broader in this field it is possible that member states will continue to prioritize different, sometimes opposing public interest objectives.[40] As well as that the additional leeway in a highly technocratic area could cause confusion and opposing legislative interpretations that can lead to a failure to achieve Union targets.[41]

3.3 Proportionality

When proposing these different action sequences for the EU, the legislator is unavoidably faced with the issue of proportionality. According to Article 5 of the TEU, under the principle of proportionality, 'the content and

[38] Ibid.

[39] Krämer (2012) 334 (10-08).

[40] See sections 8.1.4 and 8.1.3 in the Discussion chapter (Chapter 8).

[41] See section 7.4.2 of the Results chapter (Chapter 7).

form of Union action shall not exceed what is necessary to achieve the objectives of the Treaties'. Though it addresses both the regulatory and the enforcement side of proportionality the TEU's Protocol (No 2) on the Application of the Principles of Subsidiarity and Proportionality, does little to explain how to determine if a measure is proportionate to achieving a desired objective. This is because that explanation is relative and impossible to govern with a single, fixed rule. According to former Advocate General Francis Jacobs, 'whether a measure is proportionate to achieve a certain objective, environmental or other, depends, first and foremost, on the standard set by the objective to be achieved'.[42] This line of reasoning taken by the AG can be applied to the present topic, meaning that it needs to be determined whether any restrictions on free trade and competition caused by EU waste measures go beyond the inevitable restrictions justified by the pursuit of environmental protection. According to Jacobs, 'if the set objective involves a high level of protection, the restraints will inevitably also be higher. So, endorsing higher levels implies a readiness to accept more restrictive measures, as that is the very nature of proportionality'.[43] On the legislative side, actions of the Commission have illustrated that, for the Union, a high level of protection for the environment is worthy of the inevitably more restrictive measures.[44]

This type of reasoning is also supported by ECJ case law, wherein environmental protection was given a constitutional status even before a specific environmental legal basis existed in the treaties.[45] Environmental protection 'was defined as an essential objective of the Community to which, in certain circumstances and under certain conditions, the principles of free trade must defer'.[46] This is a big claim, considering the centrality of the single market as a Union objective in the founding treaties. It therefore became somewhat clear through the ECJ case-law that the bounds of proportionality can be stretched for the purposes of an objective like the environment. This claim is supported by cases like the *ADBHU* case from 1985, the *Danish Bottles* case from 1988, as well as more recently in the 2001 *PreussenElektra* case. In both ADBHU and Danish Bottles, the court confirmed that the protection of the environment constitutes one of the EU's essential objectives, and that it also constitutes one of the acceptable mandatory requirements which national authorities can rely on to restrict the entry of goods from other Member States.[47] Meanwhile in *PressenElektra*, the ECJ confirmed that a measure that essentially imposed a 'buy local' obligation on German electricity consumers was not a measure

[42] Jacobs (2006) 194.

[43] Jacobs (2006) 194.

[44] Ibid.

[45] Ibid.

[46] Ibid.

[47] Case 302/86 (Danish Bottles) Commission of the European Communities v Kingdom of Denmark [1988] ECLI 421; Case 240/83 (ADBHU) Procureur de la République v Association de défense des brûleurs d'huiles usagées (ADBHU) [1985] ECLI 51; Jacobs (2006) 188.

having equivalent effect to a quantitative restriction. No analysis of whether the provision respected proportionality was applied.

The tension around proportionality is related to VFG and sludge management too. The Member States have obliged themselves to a series of complex and unfamiliar objectives in the transition to a circular economy as part of a commitment to overall environmental conservation. These large objectives allow for even drastic measures to be potentially proportional. Going by the Advocate General's earlier logic: these objectives do involve a high level of protection, and thereby imply a readiness to accept more restrictive measures – including new targets and requirements, potentially before old ones have been fully achieved. Especially considering the widening bounds of proportionality in rulings of the ECJ in relation to measures that protect the environment, it is not surprising that this is an area in which Member States feel uncomfortable allowing a further stretching of subsidiarity and proportionality.[48]

The balancing act between these subsidiarity and proportionality tensions remains a point of contention as we advance in the Circular Economy transition. While the setting of new, stricter substantive requirements under the justification of environmental protection can be proportional and in respect of subsidiarity, it does not mean that the Union could not do more to emphasize and encourage solutions at the national or sub-national levels.

Regarding cooperation between the EU and Member States, a reasoned opinion from Austria (which is, in principle, only meant for subsidiarity concerns) puts forward a proportionality based argument, suggesting that the way the EU could do its part here is by doing more to monitor compliance with existing substantive norms (ie: the recycling and landfilling targets). This is not a new idea, as the EU has already tried to make advances in improving implementation by setting up a body which would oversee implementation and enforcement of EU waste legislation at the member state level (essentially, an EU Waste Agency).[49] This was widely unpopular with Member States, and other options had to be considered. The European Environmental Agency was an option, but it cannot work to improve transparency in Member States without a revision of its statutes.[50] Another option was IMPEL (the European Union Network for the

48 It is somewhat clear through the ECJ case-law that the bounds of proportionality can be stretched for the purposes of an objective like the environment. This claim is supported by cases like the ADBHU case from 1985, the Danish Bottles case from 1988, as well as more recently in the 2001 PreussenElektra case. In both ADBHU and Danish Bottles, the court confirmed that the protection of the environment constitutes one of the EU's essential objectives, and that it also constitutes one of the acceptable mandatory requirements which national authorities can rely on to restrict the entry of goods from other Member States. Meanwhile in PressenElektra, the ECJ confirmed that a measure that essentially imposed a 'buy local' obligation on German electricity consumers was not a measure having equivalent effect to a quantitative restriction. No analysis of whether the provision respected proportionality was applied.

49 Jackson and Watkins (2012), 11-12.

50 Ibid.

Implementation and Enforcement of Environmental Law), however, this IMPEL is currently an international non-profit, and it does not want to be turned into an EU-wide inspectorate that answers to the Commission.[51]

This all means that the proposed 'job position' for a body that could help bridge this implementation gap between Member States that are achieving waste targets and Member States that are not, remains unfilled. Considering the changing landscape of EU enforcement,[52] this empty position can be seen as an opportunity to develop a new way to tackle implementation and enforcement around complex, paradoxical topics like waste management, which do not have a 'one size fits all' solution. There has already been innovation around this in other areas of EU law (not related to the environment or waste), for instance, in the EU data protection and banking sectors.[53] Perhaps such an innovative approach could also benefit the waste sector and other phases of the VFG and sludge lifecycles.

3.4 Obstacles Relevant to VFG and Sludge

There is very little court scrutiny of subsidiarity and proportionality mechanisms specific to the central topics of this research and relatively little analysis of the legislative choices these mechanisms bring about. As argued above, the unsettled nature of the subsidiarity and proportionality mechanisms more generally, affect specifically the conferral of power around the VFG and sludge streams too. As explained in chapter 1 and 2, the present research follows the lifecycle of VFG and sludge waste materials (from production in agriculture through to treatment for recovery and the creation of new products from recovered materials).[54] Over the course of the research it will become apparent how each of these segments of the VFG and sludge materials' lifecycle is affected by the subsidiarity and proportionality mechanisms.

For the moment, it is useful to look over which legal basis relate to which segments of the materials' lifecycle. When it comes to 'production and use', the most relevant legislative areas are critical raw materials, agriculture and consumer protection. CRMs are given legal basis by Article 191 of the TFEU from an environmental perspective. However, it seems that the legal basis of

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[51] Ibid.

[52] M. Scholten, 'Mind the trend! Enforcement of EU law has been moving to 'Brussels', Journal of European Public Policy 24, no. 9 (2017): 1348-1366.

[53] Surrounding data protection the job position is filled by the 'European Data Protection Board', while in the banking sector it is the 'European Central Bank'; D. Fromage, and T. van den Brink, 'Democratic legitimation of EU economic governance: challenges and opportunities for European Legislatures' Journal of European Integration 40, no. 3 (2018): 236.

[54] See reading guide at the end of Chapter 1 'Introduction' and the in-depth explanation of the VFG and sludge materials' lifecycle throughout the whole of Chapter 2 on 'The General and Bio-Technological State of the Art for the VFG and Sludge Waste Streams'.

Article 114 is stronger as this is the article on which the proposal for the CRM Regulation is based. Relative to subsidiarity the explanatory memorandum of the proposed regulation states that 'the Regulation intends to ensure a secure and sustainable supply of CRMs for the EU. Without such efforts, current trends in supply and demand are likely to create a serious and structural risk of disruptions to the supply of a range of CRMs'.[55]

Agriculture is given legal basis through Articles 114 (to a degree) and more concretely through Article 38(2) and Article 44 – on the common agricultural policy conferred to the EU level. Alongside the specific common agricultural policy objectives, a number of Treaty provisions are becoming objectives of the common agricultural policy in their own right. This includes Article 11 on environmental protection to promote sustainable development. The environment-food link is highlighted by the inclusion of the 'Farm to Fork' strategy in the European Green Deal.[56]

Though 'use' (consumption of food by consumers) is not explored centrally in the present research, it is relevant in that public health (an important part of product use) is a competence shared between the European Union and Member States.[57] The EU's first program on consumer protection was adopted in 1957 and defined five fundamental consumer rights: the right to protection of health and safety, the right to protection of economic interests, the right to claim for damages, the right to an education, and the right to legal representation.[58] In line with subsidiarity and proportionality, EU intervention in this area has mainly come in the form of directives. There are currently around 90 EU directives that cover consumer protection issues, and that is why the *acquis* remains occasionally inconsistent and minimally harmonized.[59]

For the 'collection' part of the lifecycle the most relevant legislative areas are waste law and the environment. As discussed, the environment is given legal basis through Article 191, 192 and 193 (particularly when resource conservation and re-use is involved), but the legal basis for waste law can be more difficult to pin down. Different waste streams find their legal basis in different treaty articles.[60] The choice of the legal basis is important, because 'under Articles 192 and 193 the Member States have the right to introduce

55 Proposal for a Regulation of the European Parliament and of the Council establishing a framework for ensuring a secure and sustainable supply of critical raw materials and amending Regulations (EU) 168/2013, (EU) 2018/858, 2018/1724 and (EU) 2019/1020.

56 Commission (2020c).

57 TFEU, Article 168.

58 J. Valant, 'Consumerprotection inthe EU – Policy Overview' (EPRS Document, 2015), 4-5.

59 Ibid.

60 For vehicles the legal basis is the internal market through Article 114, for electrical and electronic equipment the legal basis is environmental and based in Articles 192 and 193 of the TFEU. While some streams have a dual legal basis, like, batteries (based in both the internal market and environmental articles).

more stringent environmental legislation, whilst under Article 114 there is a total harmonization'.[61] This legislative choice is exemplified in the already mentioned example of basing the Green Deal proposals largely in 114 TFEU 'even though their primary objective is environmental protection and the internal market objectives are less central or even peripheral'.[62]

This same dynamic is present in the 'treatment' part of the lifecycle, where the most relevant legislative area is also waste management with a legal basis in environmental treaty articles. What's interesting in this part of the lifecycle is that the 2008 version of the Waste Framework Directive (herein: WFD) stated in perambulatory clause 9 that 'an emphasis on the environmental objectives laid down in Article 174 of the Treaty would bring the environmental impacts of waste generation and waste management more sharply into focus throughout the life-cycle of resources.'[63] Article 174 is the environmental legal basis provided in the Treaty establishing the European Community. No such clause exists in the 2018 updated version of the Directive, in which Article 38a instead lays out the conferral of powers and legal basis as they relate to specific articles (ie: specific waste streams). Article 11(a) touches upon bio-waste (including VFG) for which power is conferred to the Commission for a period of five years from 4 July 2018. Seeing as this period ends at the time of writing in 2023, it will be interesting to see how the competence balance shifts in the coming period and what affect it has on the management of VFG waste. Meanwhile, management of sludge (while it is still a part of wastewater) is governed by the Urban Wastewater Treatment Directive, which finds its legal basis in TFEU Article 192(1).[64]

For the 'treatment' part of the lifecycle the most relevant question is actually who has the power to decide which type of waste installation should be used (landfill, composting plant, recycling plant, incineration plant). This choice is completely at the discretion of Member States. While Article 4 of the 2018 consolidated WFD does define the waste hierarchy, legally speaking this is only a 'recommendation' in that Member States are only required to '*encourage* the options that deliver the best overall environmental outcome'.[65]

Lastly, when it comes to the recovered materials and creation of new products part of the lifecycle, product legislation, like that on fertilizers, again becomes relevant. For sludge, the relevant legislation here is the Sewage Sludge Directive. It seems to find it legal basis in both the environmental and the common agricultural policy articles in the TFEU. For the material streams recovered from both VFG and sludge, the specific product regulations are

[61] C. Antico, 'Brief overview of the EU Waste Law and Policy' (Environmental Implementation, DG Environment Presentation, 2020).

[62] Van den Brink & Passalacqua (2023) 5.

[63] Waste Framework Directive [2008] preambulatory clause 9.

[64] European Parliament, 'Initial Appraisal of a European Commission Impact Assessment' (EP Website, March 2023).

[65] Krämer (2012) 335 (10-11).

relevant – most notably the Fertilizer Product Regulation. It finds its legal basis in the single market through TFEU Article 114. There is currently no harmonization of the bio-plastics market, though if this area were to be developed it is logical for product legislation to be based in TFEU Article 114. It is possible that this is why legislation around products in the final stages of the material lifecycle (like those made from recovered bio-plastic) is limited – because a regulation on this topic may not be seen as proportional to the objectives of Article 114.[66] This is just one example, but the tensions around competence will continue to be a running theme throughout this research because of the complex global-local nature of many of the issues discussed.

The competence settlement impacts waste legislation at each phase of the VFG and sludge lifecycles (production, use, and treatment). A broader or more narrow interpretation of subsidiarity in particular (relevant to the treatment phase of the lifecycle) would have the greatest impact on circularity of the relevant materials – driving forward the achievement of existing targets and balancing the relevant public interest objectives.

66 See section 6.3.5 of the Sewage Sludge Chapter (Chapter 6).

CHAPTER 4

Production of Foodstuff

The Legislative State of the Art for Production of Foodstuff Destined for VFG and Sludge Streams, at the Beginning of the Agri-Food Chain

The food we eat, which eventually ends up in the VFG and sludge waste streams, requires the input of raw materials as part of agricultural production. As such, the production of these foodstuffs is related to two areas of law: critical raw material use and agricultural methods of production. The relevance of both of these areas of law for the circular agri-food chain is explained here.[1] Since this part of the material lifecycle is the same for both VFG and sludge, it is explored jointly in this chapter. After this the lifecycles of VFG and sludge materials diverge (in collection, treatment and creation of new products) and are explored separately, in chapter 5 for VFG and in chapter 6 for sludge.

4.1 Critical Raw Materials Law

Although raw materials are highly important for Europe's economy, as well as the global economy as a whole, there are no binding legal frameworks for critical raw materials at the EU level, nor in Dutch and Croatian national law.[2]

There is the Raw Materials Initiative, launched in 2008, at the EU level, which has resulted in the creation and continued work on the EU's list of Critical Raw Materials. The list aims to identify the CRMs which are important for the Union from an economic perspective, while at the same time also face potential supply risks. The 2020 EU list contains 30 materials and will continue to be updated as the supply risk for materials changes.[3] Importantly for the present topic, the EU list of CRMs includes phosphorus, phosphate rock, zinc, molybdenum and boron, but not many of the other nutrients that are also at risk of being limited in the future. Phosphate rock was newly confirmed in the list as of 2020.

The EU holds direct competence in trade relations and EU-funded research and innovation, but much of the work related to protection of CRMs is believed to only be possible in cooperation with Member States, regions, industry and other stakeholders. Therefore, the Commission's communication focusses on identifying mining, processing, and recovery projects together with the Member States, to ensure that the projects provide jobs and benefit the Member States. The EU's role in this area is mainly focussed on setting strategic priorities, providing funding and mobilising actors at the national level. For example, the

1 The Agri-food supply chain includes all the processes that describe how food from a farm ends up on a consumer's table. The processes include production, processing, distribution, marketing, consumption, and disposal; S. Deekonda, 'Agri-Food Supply Chains from Circular Economy Perspective', in Handbook of Research on Designing Sustainable Supply Chains to Achieve a Circular Economy, pp. 286-305. IGI Global, 2023.

2 See sections 2.1 and 2.2 of Production and Use in the General and Bio-technological Chapter (Chapter 2).

3 European Commission, 'Tackling the Challenges in Commodity Markets and on Raw Materials' (Communication) COM(2011) 25 final, Annex II; K.J. Campbell et. al., 'Policy brief on critical raw materials and their integration in extended producer responsibility and eco-design policy' (2022).

EU's Green Deal, specifically the Farm to Fork and Biodiversity strategies, set targets to reduce nutrient losses by 50% by 2030 and reduce mineral fertiliser use by 20%.[4]

In the Netherlands, attention is being paid to CRMs. Although there is no binding legislation, there is a National Raw Materials Agreement which was signed by 180 parties in 2017. In essence, the agreement contains requirements on having the Dutch economy operate on the basis of reusable raw materials.[5] According to a study by the European Environmental Agency, the industrial sectors which the Netherlands deems to be under the greatest risk of supply insecurity for CRMs are electronics, appliances for transport vehicles (cars, ships) and a number of other smaller industries, among which agriculture is not included. However, there has been an increase in attention paid to raw materials like phosphorus, nitrogen and potassium in recent years, as evidenced by the increase in both academic and industry studies on the topic.[6] Despite conservation of CRMs not being at the top of the Dutch legislative agenda, organic waste, which VFG is a part of, is identified as one of the key value chains in the Dutch Circular Economy programme.[7]

At the national level in Croatia, there is also no binding legislation on CRMs. However, the Ministry of the Economy and Sustainable Development,[8] did develop a Mineral Materials Management Strategy, back in 2008.[9] This Strategy is mainly focussed on the use of high-quality, virgin raw materials. It also alluded to secondary raw materials being 'economically unprofitable and technically unacceptable' at the time.[10] However, this is not evidence of an unwillingness on the part of Croatia to reuse secondary raw materials, but rather a detailed insight into how attitudes towards CRMs and reuse of secondary CRMs has changed over time in the European community. A more explicit legislative or policy document to support the conservation and reuse of CRMs would be beneficial for Croatia.

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4 Commission (2020c) 9.

5 Raw Materials Agreement (Dutch: Grondstoffenakkoord), Ministry of Infrastructure and Water Management, 24 January 2017.

6 A.L. Smit et al., 'A quantification of phosphorus flows in the Netherlands through agricultural production, industrial processing and households' (2010) Plant Research International No.362; NedMag, 'Closing the phosphorus cycle' (NedMag Website, 2020; ICL Group, 'Producing Fertilizers with Recycled Phosphate' (ICL Website, 2020).

7 European Environmental Agency, 'More from less — material resource efficiency in Europe' (EEA, 2016), 10.

8 The Ministry of the Economy and Sustainable Development (recently re-named from Ministry of Economy, Entrepreneurship and Crafts).

9 Strategy Governing Raw Materials in the Republic of Croatia (Croatian: Strategija Gospodarenja Mineralnim Sirovinama Republike Hrvatske), March 2008.

10 Strategy Governing Raw Materials in the Republic of Croatia (2008) 1.2-3.

In addition to the raw material agreements and the agriculture policy described for VFG, there is also some soft law relevant to sludge, specifically at the Dutch national level;[11] these are called Raw Material Green Deals (Green Deal Grondstoffen Unie van Waterschappen, C-174). Green deals are generally made between the central government and companies, other governmental agencies and/or NGOs, in an attempt to alleviate challenges that restrict the achievement of sustainability goals. The specific Green Deal for Raw Materials is made between the central government, the Union of Water Boards (UvW) and the Foundation for Applied Water Research (STOWA).

The deal 'attempts to strengthen the economy while simultaneously decreasing the dependence on fossil energy and scarce natural resources', by 'promoting and increasing the amount of resources recovered from sewage water, particularly phosphate, cellulose, bioplastics, alginate and CO2'.[12] Through the deal, the UvW encourages 'local water authorities to draft plans for demonstrative pilots, coordination between the water authorities, signalling of regulatory hurdles, and assisting companies within the water sector'.[13] Meanwhile, the central government contributes by addressing the identified regulatory hurdles and 'facilitating technical, legal, financial, communicative and organisational advice, and actively helping water authorities to find funding for their projects'.[14]

In addition to such soft laws, there are also policy measures that target critical raw material use. For example, phosphorus taxes for usage in agriculture have already been experimented with in several European countries: The Netherlands, Sweden, Denmark, Austria, Norway and Finland. The aim of these taxes is 'largely to decrease phosphorus usage on farms for environmental reasons'.[15] The idea is that a 'tax on natural resources or primary materials could create incentives for a reduction in material use and contribute to a more sustainable use of material resources at national and international levels'.[16] The tax can be implemented at different stages of the value chain: at the phase of extraction (of the material from the ground), at the phase of material input at the first industrial use (such as the fertiliser or phosphorus tax), or at the final consumption stage.

The Dutch experience with these types of economic incentives is interesting. In 1998, the Netherlands introduced the Mineral Accounting System (MINAS), which 'targeted nitrogen and phosphate surpluses rather than inputs'.[17]

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11 P. Dijkshoorn & J. De Best, 'Legal Framework for Raw Materials from Sewage Water', 17.

12 Ibid.

13 Ibid.

14 Ibid.

15 De Boer et al. (2018) 10-11.

16 F. Eckermann, et al. 'Material Resource Taxation—An Analysis for Selected Material Resources.' European Topic Centre on Sustainable Consumption and Production & European Topic Centre on Waste and Materials in a Green Economy, Copenhagen (2015) 5.

17 'This focus has the advantage that only nitrogen and phosphate losses are taxed, not the necessary input. Farmers were obliged to declare the mineral surplus on their farm, which was based on the

Although the system proved to be effective in decreasing total nutrient losses for some farm types, its overall results are mixed and the system itself had high administrative costs. The system was abolished in 2006, as it failed to implement all elements of the EU Nitrates Directive; however, its abolition does not necessarily mean that there is no place for natural resource taxation in the Dutch legal system.[18] No such agreements or taxes exist in Croatia at the moment.

In addition to support for conservation of CRMs through the Raw Materials Initiative and related communications, the EU can also support Member State efforts in this area through an emphasis on circularity, recycling of raw materials and the creation of markets for recycled raw materials. The increase in the lifetime of a product and the use of secondary raw materials are an integral part of the transition to a climate-neutral economy and very important for the conservation of CRM. If further emphasis is placed on the issue, through policy documents such as the CE Action Plan, the retention of value for high-grade materials will help reduce CRM demand EU-wide.[19]

4.2 Agriculture Law

Agriculture often receives special treatment because it is a separate legislative area with various sectors and food chains.[20] The raw products sectors, which VFG materials fall into, are predominantly national or regional in scope, because a large number of producers sell their produce locally to wholesalers (or within the EU), who then supply local retailers and, by extension, the end-consumer.[21] As such, national law, in addition to EU law, is relevant. The CAP, established by the TFEU, is the central legislation for the agricultural sector.

Pursuant to Article 39 of the TFEU, the CAP objectives are:

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volume of nitrogen and phosphate that had been supplied to the farm in the form of fertiliser and feed and disposed of in the form of products and manure. A tax had to be paid for excess emissions above a given levy-free surplus, which was reduced over the years and tax rates increased. After a period during which it was only compulsory for large pig, poultry and dairy farms, the system became compulsory for all farms in 2001.' Eckermann et al. (2015) 40-41.

18 Eckermann et al. (2015) 40-41.

19 European Commission, 'Questions and Answers on the Communication on Critical Raw Materials' (Press Release, September 2020).

20 M.E. Ciobotaru 'Strengthening the principle of subsidiarity in the management of the Common Agricultural Policy by means of Strategic Plans-The impact on the agricultural sector in Romania' (2019) Academic Journal of Law and Governance 7(2): 78-84, 78.

21 P. Chauve et. Al., 'Agriculture, food and competition law: Moving the borders' (2014) Journal of European Competition Law & Practice 5(5): 304, 313.

1) to increase agricultural productivity by promoting technical progress and ensuring the rational development of agricultural production and the optimum use of the factors of production, in particular labour;
   a) thus to ensure a fair standard of living for the agricultural community, in particular by increasing the individual earnings of persons engaged in agriculture;
   b) to stabilise markets;
   c) to ensure the availability of supplies;
   d) to ensure that supplies reach consumers at reasonable prices.

Clauses a) and d) are particularly relevant to the topic at hand. Clause A is relevant because nutrient reuse in agriculture could contribute to the optimum utilisation of the factors of production, as well as being part of the solution to increased agricultural productivity through technical progress. Meanwhile, Clause D is relevant because the reuse of valuable raw materials (instead of their sourcing from virgin resources) helps to ensure the availability of raw material supplies and, thereby, the long-term continued success of the agricultural industry.

There are four main regulations setting out the CAP: the regulation on rules for direct payments to farmers (Regulation 1307/2013); on a common organisation of the markets in agricultural products (Regulation 1308/2013); on support for rural development (Regulation 1305/2013); and on financing, management and monitoring of the common agricultural policy (Regulation 1306/2013). Furthermore, the current common agricultural policy has two pillars. Pillar 1 enhances farm income and fosters market stability, and Pillar 2 focusses on rural development. Pillar 1 aims to achieve its goals by facilitating direct payments to farmers – for which farmers are only eligible if they comply with environmental laws ('cross-compliance') and have undertaken a number of greening measures. Pillar 2 seeks to achieve rural development through a focus on biodiversity management, competitive positioning and innovation.[22]

In addition to these important elements of the current CAP legislation, the EU's 2018 legislative proposals on the future of food and farming (herein: the new CAP)[23] seek to have a deeper and more explicit focus of nutrient management in agriculture. The two features of the legislative proposals most relevant to the present research are the greater flexibility given to Member States regarding CAP interventions and the introduction of the Farm Sustainability Tool for Nutrients.[24]

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22 L.O. Fresco & K.J. Poppe, 'Towards a Common Agricultural and Food Policy' (Wageningen University Report, 2016).

23 European Commission, 'Proposal for a Regulation of the European Parliament and of the Council establishing rules on support for strategic plans to be drawn up by Member States under the Common agricultural policy (Reg. Proposal Strategic Plans)' (Communication) COM(2018) 392 final.

24 Commission (2018), Reg. Proposal Strategic Plans, Art 12(3).

Greater intervention flexibility was introduced to address the criticisms of the previous CAP legislation as being too focussed on a 'one-size-fits-all' approach. The old CAP only gave the Member States the option to choose from a list of measures and adapt them to meet the goals of the CAP. Article 40(1) of the TFEU listed the different forms that common organisation of the agricultural market could take (common competition rules, compulsory coordination of various national market organisations, or European market organisation),[25] while Article 43 laid out how these measures are established (i.e. by EU institutions):

With the coming into force of the TFEU in 2009 the 'co-decision procedure' was extended to agriculture. Article 43 defines the new, shared competence and divides responsibilities between the Council, the European Parliament (herein: EP) and the Commission.[26] As described in the above article, the Commission submits proposals 'for working out and implementing' the CAP measures, while the legislative power is shared equally between the EP and the Council.[27]

This was the approach in the old CAP. Meanwhile, the new CAP approach gives more freedom (and responsibility) to Member States as to how they want to go about meeting the targets of the CAP. The EU aims to enable, through the enhanced subsidiarity, Member States to take care of the local conditions and needs that are unique to them, while also contributing to the common Union objectives.[28]

However, there are concerns that the increased subsidiarity could negatively affect the level playing field of the EU's agricultural sector.[29] These parties are also concerned that the new rules risk allowing states to set targets that are too low, thereby hindering the development of the Union as a whole. This is also relevant for the CAP objectives that relate to nutrient management, such as the Farm Sustainability Tool for Nutrients. The Farm Sustainability Tool for Nutrients is proposed with the aim to 'enable a platform for on-farm nutrient management that would help reduce ammonia and N2O emissions'.[30] Such a tool would compile information from satellite data, soil sampling and land

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[25] TFEU Art. 40(1): In order to attain the objectives set out in Article 39, a common organisation of agricultural markets shall be established. This organisation shall take one of the following forms, depending on the product concerned:
a) common rules on competition;
b) compulsory coordination of the various national market organisations;
c) a European market organisation.

[26] Consolidated version of the Treaty on the Functioning of the European Union (TFEU) [2012] OJ C326/47; A. Greer and T, Hind, 'Inter-institutional decision-making: The case of the Common Agricultural Policy' (2012) Policy and Society 31(4) 334.

[27] TFEU, Art 43.

[28] Commission (2018), Reg. Proposal Strategic Plans, Recital 2; Tiffanie Stéphani 'Future of the EU's agricultural policy: what about nutrient management?' (Fertilizers Europe, 2 August 2018).

[29] Ciobotaru (2019), 78.

[30] Stéphani (2018) 4.

parcel information and would be directly accessible to farmers in order to help them make informed decisions on the nutrient requirements of their crops. According to Fertilisers Europe, an organisation representing the interests of the majority of mineral fertiliser manufacturers in the EU, 'for many years, EU's agricultural policy fell a bit too short in encouraging farmers' efforts towards good nutrient management, which is crucial if the agri-food sector wants to achieve the set of EU's environmental objectives'. The Farm Sustainability Tool aims to remedy this by being a 'decision-support instrument' for farmers, rather than simply a control mechanism.

In addition to helping monitor nutrient requirements of crops, the new CAP could encourage the uptake of precision nutrition practices (also referred to as *nutrient stewardship*) by farmers.[31] This is a practice developed in opposition to the traditional farming practice of applying a flat rate of fertiliser over entire fields.[32] The updated practice of nutrient stewardship instead calls for the application of a variable rate of fertiliser on different parts of the arable land, using precise agronomy techniques to determine how much fertiliser is necessary on the different parts of land. The aim is to strike the perfect balance in achieving a smaller environmental footprint while maintaining optimal soil fertility and nutrient levels (nitrogen and phosphorus).[33] Although the practice has many benefits for farmers and their crops, it requires a lot of consistent soil sampling, data collection and monitoring. The first cross-cutting objective of the new CAP's Annex 1 (modernisation) calls for Member States to support farmers in the application of such precision farming technology.[34]

This type of 'high-level' efficient fertiliser / nutrient management will be difficult to achieve if the core agricultural targets set by the Member States under the new CAP are themselves too low. It seems that the Commission aimed to safeguard against this by including a Strategic Plans requirement for Member States as part of the new CAP. Each Member State needs to draw up a 'Strategic Plan' outlining how the CAP funding will be used to meet its needs and how its own country-specific targets will comply with, and lead up to, the achievement of overall EU objectives.[35] The old CAP only gave Member States the option to choose from a list of pre-chosen measures and adapt them,[36] while the new CAP gives Member States the freedom to develop their own measures

31 Decisive Farming, 'Precision Nutrition and Its Impact on a Sustainable Future' (PrecisionAg Website, 13 December 2019).

32 Decisive Farming (2019).

33 Ibid.

34 Ibid.

35 Commission (2018), Reg. Proposal Strategic Plans.

36 TFEU, Art 43; Ciobotaru (2019), 80; E. Erjavec et. Al., 'Research for AGRI Committee – The CAP Strategic Plans beyond 2020: Assessing the architecture and governance issues in order to achieve the EU-wide objectives' (European Parliament, Policy Department for Structural and Cohesion Policies, 2018) .

under the close supervision of the Commission.[37] Following the Member States' drafting of their Strategic Plans, the plans must be approved by the Commission, which may require changes to the plans to better align with the common goals of the Union.[38]

Considering the greater subsidiarity brought about by the new CAP, it has been predicted that relevant projects in the Netherlands and Croatia that were previously not funded because they did not fit the selection criteria could now be eligible for funding under the new rules. This would have a positive impact on the absorption rate of European funds in both Member States. In the previous programming period, the absorption rate of European funds in Croatia was about 22.6%,[39] compared to the EU average, which is 30%.[40] Among the three highest absorption rates were those from agricultural funds, with 40.4% from ERDF and 18,8% from EAFRD.[41] The Netherlands absorption rate was on average 44.7%, slightly above the EU average.[42] Similarly to Croatia, the two highest absorption rates were those from agricultural funds, with 36.1% coming from the ERDF and 33.4% from the EAFRD.[43]

As the coming into force of the new CAP in its entirety has been somewhat delayed, the deadlines for submission and approval of the Member States' Strategic Plans has also been extended.[44] As such, the CAP Strategic Plans for the Netherlands and Croatia have not yet been published at the time of completing this thesis, but there are indication as to each Member States' planned approach.

The trends in the current objectives of the Dutch government, especially the aim of establishing a circular agricultural system by 2030 with closed CE loops, are closely aligned with the new CAP objectives. At the national level, greater attention has been paid to both nutrient stewardship and circularity in the agricultural sector at large.[45] When it comes to implementation of the CAP and national agricultural policies, the implementation is partially delegated to the

37 D. Mottershead, et. Al., 'Research for AGRI Committee – Towards the CAP post 2020 – Appraisal of the EC Communication on "The Future of Food and Farming"' (European Parliament, Policy Department for Structural and Cohesion Policies, 29 November 2017); Ciobotaru (2019), 80.

38 Commission (2018), Reg. Proposal Strategic Plans.

39 European Structural and Investment Funds Data, 'SF 2007-2013 Funds Absorption Rate' (Cohesion Data, 2020).

40 Ciobotaru (2019), 81.

41 European Structural and Investment Funds Data, 'Country Data for: Croatia' (Cohesion Data, 2020).

42 European Structural and Investment Funds Data, 'Country Data for: The Netherlands' (Cohesion Data, 2020).

43 Ibid.

44 European Council, 'Extension of current CAP rules until the end of 2022: informal deal on transitional regulation' (Council Website, 30 June 2020).

45 National Institute for Public Health and the Environment (In Dutch: RIVM), 'Report on Soil ecosystem profiling in the Netherlands with ten references for biological soil quality' (RIVM Website, 2008); Government-wide programme for a Circular Dutch Economy by 2050, The Ministry of Infrastructure and the Environment and the Ministry of Economic Affairs, September 2016, 41, 42, 43.

twelve provinces. As such, the provincial governments are also actively involved in preparing the national strategic plan required by the CAP.[46]

Croatia's last Agricultural Strategy was drafted in 2001 (long before Croatia joined the EU), which is why a re-thinking of the Agricultural Strategic Plan is needed.[47] The old strategy resulted in low productivity in the farming sector when compared to other EU countries, as well as in weak links with other markets (making imported goods, which Croatia itself also produces, cheaper than the Croatian products).[48] In 2018, Croatia's Ministry of Agriculture, with the help of the World Bank, carried out a study in preparation for the drafting of the Strategic Plan that included: diagnostics of the current conditions, stakeholder consultation, as well as definition of key needs, strategic goals and activities/measures needed to achieve said goals.[49] Although a number of limitations and opportunities for growth in the Croatian Agricultural sector were identified, some of the main ones were best highlighted in an interview with Elisabetta Capannelli (the World Bank Country Manager in Croatia).[50] She explained how Croatia needs a deep transformation of the way the agricultural sector operates because while Croatia is blessed with so many advantages (geographic location, proximity to many EU markets, availability of land and water, etc), its agricultural sector is very old fashioned: focussed on primary products, lacking in competitiveness, modern technology and links to agri-food markets.[51] Capannelli believes that the new strategy developed by the Ministry of Agriculture is truly innovative, and not 'an exercise to just 'tick a box' and provide a document that the European Commission will be happy with'.[52]

The complete Strategic Plan for Croatia has not yet been published, it is assumed that many of the limitations and opportunities identified by the World Bank could be facilitated through law. According to a study by Ravenswaay and Blend, incentives that encourage adoption of innovative technologies in agriculture 'can be created by either reducing a firm's costs or increasing its revenues from adoption.'[53] This applies to the innovations brought by the new CAP as well, as the costs of new technologies (such as the Sustainability Tool for Nutrients and other nutrient stewardship techniques) can be reduced by public actors through measures such as subsidising inputs, providing technical

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46 Netherlands official reaction to the Commission's Communication 'Common Agricultural Policy towards 2020: meeting the food, natural resources and territorial challenges of the future', Dutch Government, 2010, 3.

47 L. Dabić, 'Nacrt Strategije poljoprivrede 2020.-2030. godine' (LAG Baranja Website, June 2020).

48 The World Bank, 'Croatian Agriculture – A Way Forward' (World Bank Opinion, December 2019).

49 Development Strategy for Agriculture and Fisheries (In Croatian: Strategija Razvoja Poljoprivrede i Ribarstva), 2020.

50 The World Bank (2019).

51 The World Bank (2019).

52 Ibid.

53 E.O. van Ravenswaay & J.R. Blend, 'Using ecolabeling to encourage adoption of innovative environmental technologies in agriculture' (1997) Michigan State University Staff Paper: No. 1099-2016-89140, 5.

assistance and facilitating research and development. Meanwhile, revenues for private actors spearheading these technologies can be increased by 'creating or facilitating markets for the firm's output, promoting its output, subsidising output consumption, and government purchase of the output.'[54]

The present research has only identified targets and facilitating conditions as the applied legislative and policy tools relevant for this stage of VFG materials' life cycle. Targets on the use of CRMs were set at both the EU and national levels, but none of these were binding. The identified facilitating conditions were greater levels of subsidiarity as called for by the new CAP and policy instruments like precision farming through nutrient stewardship. Monetary incentives are overlooked as a tool in this stage of the cycle, even though tools like taxes on the use of (raw) materials could play a role in disincentivising the use of non-renewable virgin materials in agriculture, steering producers towards the use of fertilisers and soil improvers made from reprocessed biomass.[55]

54 Van Ravenswaay & Blend (1997), 5.

55 P. Söderholm, 'Taxing virgin natural resources: Lessons from aggregates taxation in Europe.' Resources, conservation and recycling 55.11 (2011): 911-922.

CHAPTER 5

Legislative Framework for VFG Waste Stream

The present chapter will explain the legislative state of the art as it relates to VFG materials once they become waste, i.e. after the 'production of foodstuff' and 'use' stages of their life cycle. The remaining three stages are collection, treatment (recycling, recovery, reprocessing) and the creation of products from recovered materials.

5.1 Collection

Before encouraging various preferable collection and treatment methods, it was a key EU objective to minimise disposal of all waste in landfills. The 1999 Landfill Directive obliged Member States to reduce the amounts of biodegradable waste (including VFG and sewage sludge) being sent to landfill 'to 35% of 1995 levels by 2016'.[1] As a result, at an EU-wide level separate collection with the aim of treatment is the preferred VFG disposal route. As we have seen in the chapter on general VFG collection, separate collection facilitates the subsequent treatment of VFG waste (in line with the waste hierarchy).

Separate collection of waste is defined in EU law as the collection method where a waste stream is kept separately by type and nature to facilitate a specific treatment.[2] Article 10 of the WFD links separate collection with recovery operations, requiring Member States to take the necessary measures to ensure that waste undergoes relevant recovery operations (Article 10(1)), while also specifying that waste should be collected separately to facilitate and improve said recovery operations (Article 10(2)). In addition to this, Article 10(3) offers four far-reaching derogations from paragraph two, including a derogation in the case that 'separate collection would entail disproportionate economic costs'.[3]

Article 11(1) of the WFD further sets the requirements for European Member States to promote high-quality recycling through their waste collection systems. Article 11(2.c) makes this more concrete, setting a target for a 55% increase in recycling and preparation for reuse of municipal waste by 2025. According to the Commission, it is improbable that environmentally less advanced Member States will independently take steps to increase reprocessing of VFG waste.[4] The intention of this target is to steer all Member States towards a common reprocessing goal. Studies on these types of targets have identified some concerns, including that, since the target is weight-based, it favours large and heavy waste streams. This could mean that certain smaller flows with equal or greater resource efficiency and environmental benefit could be seen as 'insignificant' by Member States and therefore not pursued in national reprocessing strategies.[5]

1 Landfill Directive [1999].

2 Waste Framework Directive [2018] Art. 3.

3 Waste Framework Directive [2018] Article 10(3.d).

4 Commission, 'Accompanying the Communication from the Commission on future steps in bio-waste management in the European Union' (Commission Staff Working Document) SEC(2010) 577 final, 18.

5 M. Arm, et. Al., 'How does the European recovery target for construction & demolition waste affect resource management?.' Waste and biomass valorization 8, no. 5 (2017): 1491-1504, 1491.

An example is heavier, bulky garden waste being favoured over lighter fruit and vegetable waste from kitchens. Food waste tends to be more biodegradable and leads to higher recovery potentials; however, garden and park waste is heavier. Weight-based targets could incentivise Member States to focus on collecting more garden waste (to meet targets, instead of food waste – thereby leading to lower recovery potentials of the materials in the reprocessing phase).

Another concern is that the target does not 'distinguish between the various recovery processes', meaning that resource efficient and environmentally safe recovery does not have to be given priority.[6] There is also no overarching definition of environmentally safe recovery, meaning that different standards may exist across the board. For Member States wanting to ensure their reprocessing is as environmentally friendly and circular as possible, targets more relevant to these types of goals have to be implemented at the national level. It is important to highlight here, that there is no EU target for separate waste collection. The 55% target is a reuse and recycling target, and though separate collection can aid Member States in improving their reuse and recycling, the link is not explicit in the existing legislation.

Alongside Article 11, the revisions of Article 22 call for Member States to implement a system where bio-waste is either separately collected or recycled at its source by 31 December 2023.[7] As well as calling upon the Commission to 'carry out an assessment on the management of bio-waste' and set 'minimum requirements for bio-waste management and quality criteria for compost and digestate'.[8] Many Member States and stakeholders have called on this type of minimum criteria at the EU level in order to enhance user confidence in compost, thus 'strengthening the market and supporting the EU's policy towards a material efficient economy'.[9]

This work is underway through the European Compost Network, but it is not yet complete. However, the requirements themselves already indicate that a more serious approach to bio-waste is on the agenda for the future. To encourage this development the WFD also highlights that Member States should, among other actions, promote 'the use of environmentally safe materials produced from bio-waste'.[10] It is clear from the directive that the Commission is working on both preparing Member States for any eventual, concrete targets around bio-waste and on setting up a system for how these targets will be measured and reported. Finally, and very importantly, the WFD's final chapters address reporting and enforcement. Article 34 requires periodic inspections by competent authorities of relevant reprocessing installations.

When it comes to the enforcement of these new requirements, there are EU-wide standards on inspection and reporting. The inspection standards are

6 Arm et al. (2017) 1491.

7 Waste Framework Directive [2018] Article 22.

8 Waste Framework Directive [2018] Article 22; Commission Communication (2010), 17.

9 Commission Communication (2010), 9.

10 Waste Framework Directive [2018] Article 22(2.c).

outlined in Article 34 of the WFD, with Article 34(2) in particular requiring that inspections concerning collection and transport operations cover the origin, nature, quantity and destination of the waste collected and transported. Article 35 further requires waste holders at various stages of the waste treatment chain (transporters, dealers, brokers) to track and report a series of waste characteristics (quantity, nature and origin of that waste and the quantity of products and materials resulting from preparation for reuse, recycling or other recovery operations, frequency of collection, treatment method foreseen in respect of the waste, etc). In addition to inspection, Member States have various reporting obligations concerning implementation of waste legislation, with the two main reporting methods being 1) reporting on targets, and 2) submitting implementation reports.[11] The reporting on targets is done on an annual (or bi-annual) basis, with the targets reported varying on everything from waste collection, reuse, recycling and recovery of various waste streams. These reports are sent directly to Eurostat.[12] The implementation reports, on the other hand, are sent directly to the Commission's Environmental DG on a yearly basis and cover the main aspects of implementation of waste legislation.[13]

There is no relevant case law on separate collection at the EU level, but some EU-wide studies on the topic have been done to assess the different approaches to the waste separation targets. One such study found that the percentage of recyclable materials in Member States increases when municipalities introduced door-to-door collection systems, as well as that these systems provide the highest recycling rates and the best quality of recyclables.[14]

5.1.1 The Netherlands – VFG Collection

The Netherlands is pushing to be a step ahead of the EU when it comes to separation of waste for collection, having set the national target for separately-collected waste at 75% by 2020, including a reduction in how much residual waste every inhabitant is permitted per year (100 kg). These requirements are outlined in the Dutch government's 'Household Waste Implementation Programme' (VANG 2019-2023).[15]

In the Netherlands, the EU's WFD is transposed into domestic law mainly by the Environmental Management Act (Wet Milieubeheer, Wm, 1979).[16] The Wm is a broad framework law with rules on various subjects, which have been further elaborated in implementing decrees. Chapter 10 of the Wm deals with

11 Commission, 'Reporting on implementation of waste legislation' (EC Website, 2020).

12 Commission Website, 2020.

13 Ibid.; Urban Waste-water Treatment Directive [1991].

14 European Commission Environmental DG (November 2015) 11.

15 1st VANG-HHA, 'Het programma: Met optimale afvalscheiding naar hoogwaardige recycling' (VANG Website, 2023).

16 Commission, 'National factsheet on separate collection – Netherlands' (Municipal Waste Europe Website, 2014c), 1.

waste substances, with Article 10.21(2) calling specifically for the separate collection of various waste streams – including bio-waste. This puts Dutch national law in compliance with the WFD, but there are some deviations specific to Articles 11 and 22. In the WFD, Article 11(1) states that 'by 2015 separate collection shall be set up for at least the following: paper, metal, plastic and glass'. This is not transposed into Dutch national legislation. Instead, specific rules governing collection are laid down in provincial and municipal by-laws, rather than national frameworks.[17] As such, instead of direct transposition, the Netherlands ensures these requirements are met through framework contracts between municipalities, the industry and the government.[18] Furthermore, there is also a slight deviation in the transposition of Article 22, regarding the separate collection of bio-waste. Article 10.21(1) of the Wm only requires every municipality to ensure that household waste, excluding bulky household waste, is collected at least once a week from all the premises situated within its territory. Deviation from this weekly collection obligation for VFG waste is possible in the interest of efficient management of waste.[19]

In addition to the Wm, any work relating to waste streams, including VFG, starts with the National Waste Management Plan (the LAP), which is the policy framework for waste in the circular economy. Any public or private actors that want to do something with waste must consult the most recent version of the LAP – currently the LAP3 from 2017. The general policy framework in the LAP is further elaborated by the various sector plans for specific waste streams. Sector plan 6 discusses 'Separately-collected / delivered vegetable, fruit and garden waste from households (kitchen and garden waste)'. The name of the sector plan itself indicates the requirement that VFG household waste should be separately collected, but this is further emphasised in part V.1, which specifies points of attention with regard to keeping VFG waste separated throughout the entire chain. The sector plan defines VFG waste as 'organic waste from households concerning both separately collected and separately delivered vegetable, fruit and (fine) garden waste'.[20] The emphasis on fine garden waste, specifically excludes bulk garden waste, which could interfere with the waste reprocessing methods that follow collection.[21] In this regard, the LAP is up to date with current biotechnological requirements for VFG treatment.

In addition to waste-related legislation, improvements in Dutch waste collection systems can also be attributed to the landfill tax that was in place from 1995

17 Commission (2014), 1.

18 Commission (2014), 6.

19 Article 10.26 Wet Milieubeheer (Eng: Environmental Conservation Act).

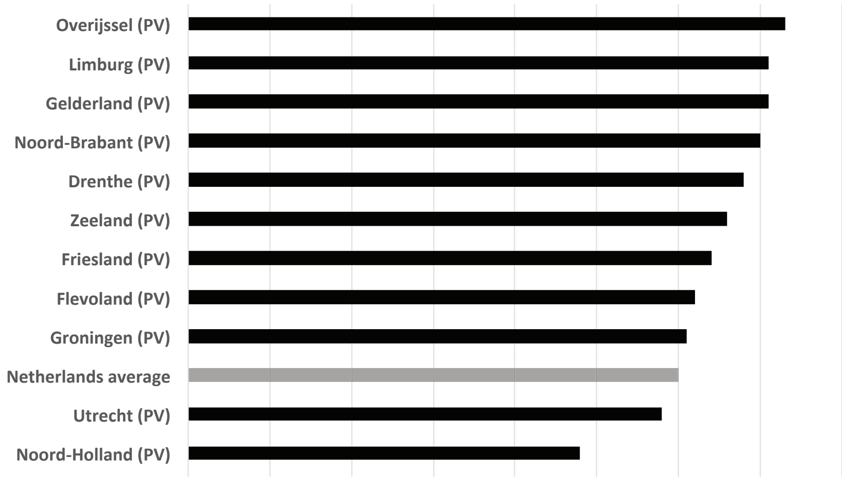
20 LeAF Report, 'Kleinschalige verwerkingsmethoden voor gft en swill – bijdragen aan de circulaire economie binnen bestaande regelgeving en beleid.' (March 2020), 3-5; The LAP3 also provides a non-exhaustive list of materials deemed to be organic waste: peels and scraps of vegetables; fruit and potatoes; leftovers from cooked food; weeds and other fine garden waste such as twigs and leaves; food that is past its use-by date; food that is past the best before (best before) date.

21 LeAF Report (2020) 5.

to 2012. Studies have demonstrated that the landfill tax significantly contributed to the reduction in waste generation by 'making waste disposal more expensive and at the same time promoting recycling and incineration as more attractive waste management options'.[22] The landfill tax was removed in 2012 because landfilling was so significantly reduced that revenue from the tax decreased to the point where the tax's existence was more an administrative burden than an instrument for the achievement of the desired goal.[23] However, if the Netherlands struggles to meet new EU waste targets, it still has this type of tool at its disposal with which it can ensure compliance.

Considering that so much of the responsibility over VFG collection rests with provinces and municipalities, it is useful to look into how they approach collection. In the below chart, we can see that in 2019 the three Dutch provinces with the highest rates of separate collection were Overijssel, Gelderland and Limburg, while the three with the lowest rates were South Holland, North Holland and Utrecht. These are the most densely populated areas of the Netherlands.

Figure 7: Percentage of separate waste collection in the Netherlands, by province (2019)[24]



It should be noted that population size, population density and the urban or rural nature of a province, affect the ability of local authorities to ensure effective waste collection systems. Multiple studies have reflected on the different challenges that both urban and rural environments provide when it comes to

[22] European Environmental Agency, 'Municipal waste management in the Netherlands' (EEA Website, February 2013), 12.

[23] Ibid.

[24] CBS (Statistics Netherlands), 'Municipal waste; quantities' (CBS Website, 2022).

waste collection.[25] However, the national and EU recycling targets are relevant for all regions, so there is value in looking at the various collection practices in different regions, as well as the by-laws which enact them, to see what lessons can be drawn and shared. The present research will do this for the Dutch province with the highest separate collection percentage (Overijssel) and the province with the lowest separate collection percentage (South Holland).

Certain intricate topics, such as the living environment (and waste therein), are mentioned broadly in provincial by-laws (Dutch: Provinciale Omgevingsverordening) and then implemented more concretely through municipal waste policies and waste collection plans. The provincial by-laws of the Province of South Holland and the Province of Overijssel find their legal basis in the Wm and other national legislation relevant to the environment.[26] In South Holland, the provincial by-law currently in force is the 2019 environmental and planning by-law (Dutch: Omgevingsverordening Zuid-Holland).[27] However, a new by-law is in the works and will come into force in January 2024.[28] The 2019 version makes no reference to VFG and no specific reference to required separate waste collection practices (for any waste stream). The focus of waste-related segments of this by-law is mainly on landfilling – rules on closed landfills (Article 3.42), rules on prohibited activities in relation to landfilling (Article 3.45) etc. The draft of the new environmental by-law for 2024 makes mention of appropriate preparation of waste for reuse and recovery in relation to water-extraction areas and groundwater protection zones.[29] There is no mention of VFG, organic waste or separate collection, but this is because the Dutch provincial by-laws are intended to mainly focus on procedure and much less on substantive issues.

Meanwhile, in Overijssel, the provincial by-law currently in force is the 2017 environmental by-law. This by-law makes no reference to VFG, organic waste or separate collection, but is instead focussed on radioactive waste and wastewater.[30] The province of Overijssel is also planning to implement a new environmental by-law, although it is not yet clear precisely when it will come into force. The draft version available online currently makes no mention of waste at all.[31]

The provincial by-laws are intended to be a bit more distant from content-based topics like separate collection, dealing with broader, safety-related waste issues. This means that most of the substance-oriented work regarding separate collection is left to municipalities. This is the point where correct

25 Dijkgraaf and Gradus (2017), 503.

26 Ordinance of the Provincial Council of South Holland of 20 February 2019 (PZH-2019-677696264) containing rules on the protection and use of the physical living environment (Environmental Ordinance South Holland).

27 Environmental Ordinance South Holland (2019).

28 Environmental Ordinance South Holland for 2024 (2021).

29 Environmental Ordinance South Holland for 2024 (2021), Article 3.3.8.

30 Geconsolideerde Omgevingsverordening Overijssel (2017).

31 Geconsolideerde Omgevingsverordening Overijssel (2017).

implementation of EU legislation goes beyond simply transposition, to include practical implementation as well. The table below summarises the different legal and policy instruments that are, or could be, established by municipal policies and waste collection plans. The present research will look at the application of these instruments to the separate collection of VFG in the two provincial capitals and in two municipalities with a low population and low population density. The former are intended to be representatives of more urban municipalities, while the latter are intended to be representatives of more rural municipalities. For the province of South Holland, the provincial capital is Den Haag, with a population density of 6,644/km².[32] While a more rural municipality is Westvoorne, with a population density of 280.2/km². As for the province of Overijssel, the provincial capital is Zwolle, with a population density of 1,169/km²,[33] while the more rural province is Ommen, with a density of 101.7/km².[34]

For collection, the identified facilitation conditions were information and collection methods (kerbside collection and drop-off collection). Kerbside or door-to-door collection requires less effort from the individual (i.e. only separating and leaving their waste on the kerbside on the correct day of the week), while drop-off collection requires slightly more effort (i.e. the individual transporting their own separated waste to neighbourhood drop-off points).

Studies have shown that there are differences in which method is most effective for different waste streams.[35] For example, for aluminium and glass, there is no relationship between collection methods and quantity of waste correctly separated, whereas for plastic there is a significant relationship between an increase in kerbside collection services and the amount of plastic correctly separated for recycling.[36] There are no relevant studies on this relationship for VFG collection; however, there is significant evidence that frequent kerbside recycling services and an increase in conveniently located drop-off points increase separate collection and recycling rates.[37] This is because of the convenience both provide. Past studies have suggested that 'without accessibility to recycling facilities, participation rate drops even in presence of positive attitude and high environmental awareness', meaning that households' low participation rate in recycling is the result of 'constraints from external conditions'.[38]

The relevant monetary incentives were waste collection charges, industry subsidies and penalties. Waste collection charges refer to initiatives like pay-as-you-throw and UBP. These initiatives use usage-pricing models in which users are charged a rate based on how much waste they present for collection (the less

32 City Population, 'Netherlands: Administrative Division' (City Population Website, 2023).

33 City Population (2023).

34 City Population (2023).

35 Dijkgraaf and Gradus (2017) 502.

36 Ibid.

37 Dijkgraaf and Gradus (2017) 503.

38 B. Chen and J. Lee, 'Household waste separation intention and the importance of public policy.' (2020) International Trade, Politics and Development: 61-79, 66.

they present, the less they have to pay). They are known to stimulate separation of waste and encourage more creativity in reducing waste generation in the first place. Several Dutch municipalities have already introduced UBP of unsorted and waste and have found sizeable and significant effects, resulting in less unsorted and more recyclable waste.[39] However, this system may not be possible in all cities, particularly larger cities, where controls and enforcement are more difficult to carry out.

Penalties for individuals/household are considered to be affective here, as they target those who abstain from separating certain waste streams as required by local by-laws.[40] It has been found that an increase in penalties can significantly 'decrease households' perception of difficulties and impossibility of recycling'.[41]

Because municipalities play an important role in waste collection and disposal, they each draw up a plan for how to approach collection and often also a supporting policy. The policy deals with all aspects of waste and is the basis for a plan for the implementation of collection. The research method for this segment was to use the municipal plans and policies to identify which of the above-mentioned policy tools are implemented in which municipalities and to what extent they have served the goal of separate collection. A breakdown of each municipality's use of the various instruments is provided in Appendix 3, while a more general breakdown of the collective findings is provided here in Table 3.

		Facilitating Conditions			Monetary Incentives		
		Information	Kerbside	Dropoff Points	Collection charges	Industry Subsidies	Penalties
SH	Den Haag	2	1	1	0	0	0
	Westvoorne	2	2	2	0	0	1
O	Zwolle	1	1	2	1	0	0
	Ommen	1	1	0	1	0	0

39 Dijkgraaf and Gradus (2017) 502.

40 Z. Wang, J. Huo & Y. Duan, 'The impact of government incentives and penalties on willingness to recycle plastic waste: An evolutionary game theory perspective' (2020) Frontiers of Environmental Science & Engineering, 14, 3.

41 A. Farshad Amini, J, Ahmad and A.R. Ambali. 'The influence of reward and penalty on households' recycling intention.' APCBEE procedia 10 (2014): 187-192, 190.

(Grading scale 0-2, where 0 indicates that the instrument is 'not used at all', 1 indicates the instrument is 'used but not to its fullest potential' and 2 indicates that the instrument is 'used maximally').[42]

Table 3: Policy instruments to encourage separate collection of VFG by municipality

Example 1: Findings for Den Haag

In Den Haag, the 'Waste policy in the municipality of Den Haag' was drawn up in 2008, and it puts organic waste and VFG at centre stage.[43] The policy was used as a basis for the 'Household Collection Plan' for the period from 2016 to 2020, which focussed explicitly on separate collection.[44] Generally, the policy can be considered in compliance with the EU's WFD.

Example 2: Findings for Westvoorne

Westvoorne's central 'Waste Materials Ordinance' came into force in 2016.[45] There is an entire article explicitly stating and explaining the separation of waste within the municipality, with VFG being one of the streams collected separately.[46] Even though this is the only relevant mention of VFG waste in the Ordinance, it does put Westvoorne in compliance with the EU's WFD. Beyond the Ordinance, there are no further waste policies or waste plans, but there is further clarification of the municipality's waste collection protocols on their official website.

Example 3: Findings for Zwolle

In Zwolle, the latest 'Waste Materials Ordinance' came into force in 2011.[47] The Ordinance frequently mentions VFG waste and collection thereof. It also makes continuous references back to the national legislation around VFG collection and the situations in which exceptions for collection can be made.[48] The Ordinance also mentions collection of VFG waste in relation to prevention of diffuse

[42] Because the given instruments are of a varied nature, there are different criteria for the numbered grades of each instrument. For example, for the instrument 'Information' a grade 1 is given if the municipality does offer some information on its website on how to separate waste, while a grade 2 is given if the municipality gives more extensive, easy to understand information (like instructions for separation by waste stream). In a further example, for the instrument 'Drop-off Points', a grade 1 is given if some drop-off points are offered throughout the municipal territory (however, they may be rare), while a grade 2 is given if the drop-off points for various waste streams are plentiful and located conveniently throughout many neighbourhoods of the municipal territory. Such a distinction between grade 1 and 2 can be made for all the instruments and is further clarified and elaborated upon below, when discussing the application of these instruments in each of the respective municipalities.

[43] Haags Milieucentrum, 'Afvalbeleid in de gemeente Den Haag' (Den Haag Council Website, 2008).

[44] Den Haag Council, 'Afval scheiden, gewoon apart! - Huishoudelijk Afvalplan Den Haag 2016 – 2020' (Den Haag Council Website, November 2015).

[45] Afvalstoffenverordening Westvoorne 2016.

[46] Afvalstoffenverordening Westvoorne 2016, Article 7(2)

[47] Afvalstoffenverordening Zwolle 2011.

[48] Afvalstoffenverordening Zwolle 2011, Article 3(3)

environmental pollution (Article 20), making the explicit connection between waste and environmental degradation clear.[49] The Ordinance is expanded upon in Zwolle's 2016 'Municipal Raw Materials Plan'.[50]

The municipality plans to continue working on its collection and treatment methods focussing on three areas: providing good information about waste separation, providing better separation facilities and offering financial rewards for successful waste separation. Considering all this, Zwolle is in compliance with the EU's WFD.

Example 4: Findings for Ommen

The most recent 'Waste Material Ordinance' for Ommen came into force in 2010. The Ordinance makes a few references to VFG collection, specifically in regard to frequency of collection and prevention of diffuse environmental pollution.[51] In addition to the waste material Ordinance, in 2021 Ommen passed a 'Waste tax Regulation', updating its waste collection rates, which are charged per emptying. As such, Ommen is in compliance with the EU's WFD.

There seem to be no major legislative gaps in the Netherlands when it comes to tools for collection. Most Dutch municipalities are making use of the more common tools (access to information, door-to-door collection and conveniently located waste drop-off points) to encourage separate waste collection. Of the four municipalities discussed here, only Zwolle has introduced a more novel scheme, such as pay-as-you-throw. At the municipal level, relatively little attention is paid to industry subsidies, and no attention at all is paid to penalties. It seems that the main difference between both the provinces with the highest and lowest waste separation rates, and between the neighbourhoods of a municipality that separate and do not separate VFG waste, is the urbanisation of the area. This is not to say that urban municipalities are doing a worse job at setting up separate collection initiatives, but rather that they face a greater challenge due to the larger number of high-rise buildings and densely populated areas.

5.1.2 Croatia – VFG Collection

Interestingly, Croatian legislation does not speak of a 'VFG' waste stream, but instead divides bio-waste into four categories. According to the 'Catalogue of Municipal Bio-waste', bio-waste can be 1) biodegradable waste from kitchens and canteens;[52] 2) edible oils and fats;[53] 3) biodegradable waste from gardens and parks or;[54] 4) waste from markets.[55]

49 Ibid.

50 Grondstoffenplan Zwolle 2017.

51 Afvalstoffenverordening van de Gemeente Ommen 2010, Article 5 and 20.

52 Izvod iz Pravilnika o katalogu otpada (NN 90/15), key number: 20 01 08.

53 Izvod iz Pravilnika o katalogu otpada (NN 90/15), key number: 20 01 25.

54 Izvod iz Pravilnika o katalogu otpada (NN 90/15), key number: 20 02 01.

55 Izvod iz Pravilnika o katalogu otpada (NN 90/15), key number: 20 03 02.

In Croatia, the EU's WFD is transposed into national legislation by the Law on Waste Management (herein: ZGO, HR: Zakon o gospodarenju otpadom, previously known as the 'ZOGO') and the Ordinance on Waste Management (HR: Pravilnik o gospodarenju otpadom, NN 81/2020). Croatian national legislation is in full conformity with the WFD, in terms of transposition.[56] Issues arise only in terms of implementation and compliance. Past research of effective implementation of EU waste law in Croatia has suggested that ongoing procedures to amend national laws should focus on compliance with the Landfill Directive and waste collection targets for specific waste streams, including bio-waste.[57]

Croatia has not yet been able to meet EU waste collection targets, which will likely continue to become stricter and more ambitious. The separate collection targets are linked to targets for reducing landfilling from the 1999 Landfill Directive, because separately collecting and treating waste contributes to shifting waste away from the landfill towards recycling. Currently, Croatia is landfilling 72% of its municipal waste, a percentage significantly above the target of the Landfill Directive and the EU average of 24%.[58]

Waste collection targets for bio-waste in Croatia are outlined in policy documents, such as the Waste Management Plan of the Republic of Croatia for the period from 2017 to 2022. These waste management plans are implemented every five years and the latest plan (# 3) sets some ambitious targets for separate collection. Target 1.3 of the plan hopes to achieve 40% separate collection of bio-waste from what would usually be the residual waste stream. Three measures to achieve this target were laid out:[59]

- The development of quality criteria and labelling of compost and digestate;
- Procurement of equipment and vehicles for separate collection of bio-waste;
- Construction of a plant for biological treatment of separately-collected bio-waste.

This is an ambitious goal, considering that most bio-waste in Croatia is not collected separately from residual waste, and most ends up being landfilled. Only 29% of local self-government units (roughly speaking, the equivalent of municipalities) separately collect bio-waste and of the ones who do: most of their collected bio-waste is from gardens and parks.[60] In 2018, the amount of separately-collected waste was around 70,000 tonnes, which is only 13% of the

56 Commission, 'Environmental Implementation Review' (European Commission Website, 2023).

57 Commission (2023), 8.

58 Ibid.

59 'Odluka o donošenju Plana gospodarenja otpadom Republike Hrvatske za razdoblje 2017. – 2022. godine' NN 1/2022, Section 7.1, Table 14.

60 In separately collected quantities of municipal biowaste, about 69% is biodegradable waste. From gardens and parks (KB 20 02 01), about 19% biodegradable waste from kitchens and canteens, about 8% edible oils and fats and 4% market waste; Izvjesce o komunlanom otpadu 2019, p. 20.

total amount of bio-waste produced. At the time of writing, Croatia has not yet released the new waste management plan for the period from 2023 to 2028.

Other relevant legislation in this area includes the ZGO. The article relevant to separate collection of bio-waste is Article 55 (1), which sets out landfilling targets for municipal bio-waste, stating:

> 'The maximum permitted mass of biodegradable municipal waste, in a calendar year can be allowed by all waste management permits in a calendar year within the Republic of Croatia, is 264,661 tonnes, which is 35% of the mass of biodegradable municipal waste produced in 1997.'

In 2018 the amount of bio-waste landfilled was 744,506 tonnes, meaning that neither the 2013, nor the 2016 targets were met.[61] Considering this lag in achievement of EU targets, Croatia has been the target of the Commission's Early Warning Report in 2018. The general issues which created the need for an Early Warning Report (herein: EWR) in the Member States concerned were related to the improvement of municipal recycling targets and landfilling targets.[62] The Commission outlined how the legal obligations in the WFD, concerning the management of municipal waste were at a danger of not being met.[63]

The Commission thereby identified four central problem areas in Croatia's compliance with EU waste legislation, outlined in the EWR specific to Croatia:[64]
- the separate collection of recyclables, including bio-waste, is not yet being carried out effectively;
- economic incentives for citizens and municipalities have not yet been implemented;
- the extended producer responsibility schemes in Croatia do not fully cover the costs of separate collection;
- more investment is needed in projects higher up the waste hierarchy that go beyond the treatment of residual waste.

The Commission made several recommendations to Croatia, which could all be addressed through legislation to some degree.[65] It also had some economic

[61] Požgaj, Đurđica, Eda Puntarić, Marcela Kušević – Vukšić, Jasna Kufrin, 'Izvješće o komunalnom otpadu za 2018. godinu' (Ministarstvo zaštite okoliša i energetike, December 2019), p 9p. 9.

[62] Commission, 'Report on the implementation of EU waste legislation, including the early warning report for Member States at risk of missing the 2020 preparation for re-use/recycling target on municipal waste' (Communication, September 2019c) 656 final..

[63] The member states concerned were: Bulgaria, Croatia, Cyprus, Estonia, Finland, Greece, Hungary, Latvia, Malta, Poland, Portugal, Romania, Slovakia and Spain.

[64] Commission Staff Working Documents, 'Early warning report for Croatia' SWD (2018) 414 final.

[65] Ibid.

recommendations (such as revising spending priorities of EU funds to bring them in line with initiatives like that of separate collection).[66]

The Commission believes that the above recommendation, coupled with active sharing of good ideas and practices, can improve efficiency in terms of cost reduction and performance of the waste sector in Croatia. However, a key component of these improvements is the regular participation of relevant stakeholders in Croatia, both in the original construction of the EWR and in the follow-up work.

This follow-up work to ensure compliance is done jointly by the national, regional and local government units. The ministry in charge of waste management at Croatia's national level is MINGOR. An important role in waste management is also played by different local self-government units (HR: jedinice lokalne samouprave, herein LSGUs). LSGUs are, roughly speaking, the equivalent of municipalities when drawing a parallel with the Dutch system.

To achieve compliance with the EU's Landfill Directive and to monitor the achievement of reducing disposal of bio-waste, Croatia and the other EU Member States are required to submit reports to the EC on the quantities of landfilled biodegradable waste (including VFG).[67] Croatia does this through the landfill database, which is part of the Waste Management Information System.[68] The system is called e-ONTO and it stores all the reporting and monitoring information on waste streams in Croatia.

Beyond monitoring, the ZGO also distributes the competences between regional authorities (counties) and LSGUs. The law designates LSGUs with the responsibility of preparing local waste management plans, which are adopted for a period of six years. The LSGU is obliged to submit an annual report on the implementation of its waste management plan to the county.[69] Following this, each year the county's administrative body is obliged to submit an annual report on the implementation of the National Waste Management Plan to MINGOR.[70]

This monitoring and reporting system is an example of the interplay between the different levels of governance in the collection of Croatian waste. Obligation on what type of data is to be monitored and reported is set out in the aforementioned Ordinance on Waste Management and in the 2015 Ordinance on the register of environmental pollution (HR: pravilnik o registru onečišćavanja okoliša). The various waste collectors enter the necessary data into the monitoring system. The county's administrative bodies, in cooperation with the relevant inspection authorities, are responsible for ensuring the completeness, consistency and credibility of the data entered into the system by waste collectors.

66 Commission (2023) 8.

67 Croatian Agency for the Environment and Nature (2018) 17.

68 Ibid.

69 Law on Waste Management (Hr: Zakon o gospodarenju otpadom, ZGO) NN 84/2021, Article 69, 82, 111.

70 Law on Waste Management (ZGO) NN 84/2021, Article 114 and 173.

The responsibility for collection of mixed municipal waste and municipal bio-waste is largely shared by the administrative bodies in each of the counties and the national administrative body, MINGOR. The setting of prices for the mandatory minimum public collection services, contractual penalties and penalties for inappropriate waste disposal are all set, supervised and enforced by MINGOR. The counties set overarching goals and plans for waste collection and reprocessing, which apply throughout the county, while the LSGUs are responsible for carrying out the waste management plans.[71]

In addition to monitoring, there is another route taken by the Croatian national authorities to improve waste collection: penalties and incentives. Articles 99, 100, 101 and 105 of the ZGO outline the financial penalties and incentives. Article 99 starts with some incentives, listing out 22 central government 'incentives and grants in waste management', among which are the promotion of use of materials made from bio-waste, development of secondary raw materials markets and co-financing the construction of waste recycling plants, waste sorting plants and composting plants in order to achieve highly efficient recycling.[72]

Article 100 of the ZGO is interesting because it calls for the implementation of a landfill tax – a measure that has been shown to improve the separate collection of waste fractions such as VFG,[73] and therefore also a measure that would bring Croatia closer to meeting the recommendations of the Commission's 2018 Early Warning report. Despite the existence of Article 100 and the outcomes of various studies to determine how such a tax could benefit the current system,[74] no implementing legislation has been passed to activate the landfill tax in practice. Without the implementing legislation, called for by Articles 100(3) and 100(6) that would set up the system surrounding the landfill tax (prices, quantities, inspections, enforcement) no landfill tax is currently implemented in practice.

Article 105 goes even further by putting in place a waste management tax.[75] The waste management tax is paid by the producer of the product when they place on the market a product of the type for which the tax obligation is prescribed. The tax obligation is determined annually by FZOEU for different categories of products and includes consideration of (among other things) the life cycle of the products and the possibility of recycling the waste from the

71 Law on Waste Management (ZGO) NN 84/2021, Section XVIII., Article 173-174.

72 Law on Waste Management (ZGO) NN 84/2021, Section XI., Article 99.

73 Aside from waste related legislation, improvements in Dutch waste collection systems can also be attributed to the Landfill tax which was in place from 1995 to 2012. Studies have demonstrated that the landfill tax significantly contributed to the reduction in waste generation by 'making waste disposal more expensive and at the same time promoting recycling and incineration as more attractive waste management options'; European Environmental Agency (2013), 12.

74 Croatian Agency for Environment and Nature (2018), 17.

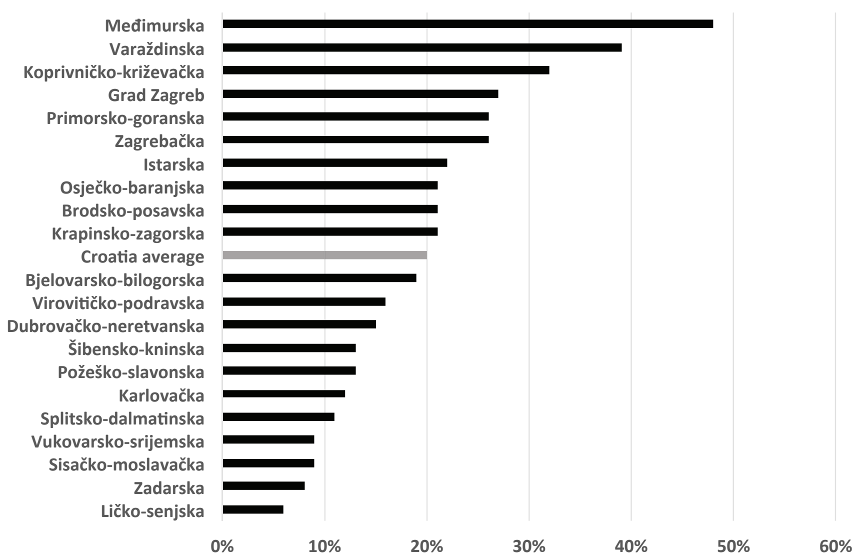
75 Law on Waste Management (ZGO) NN 84/2021, Article 100 and 105.

products. This is the Croatian transposition of extended producer responsibility as it relates to waste, but it currently applies only to electronics.[76]

Counties

There are quite some differences in the approaches to waste collection, particularly separate waste collection, taken by the various counties. In the figure below, we can see that in the most recent complete data from 2018 the three Croatian counties with the highest rates of separate collection were Međimurska, Koprivničko-križevačka and Varaždinska, while the three with the lowest rates were Ličko-senjska, Vukovarsko-srijemska and Zadarska. The three with the lowest rates, along with eight other counties, are all below the Croatian average of 17% separate collection.

Figure 8: Percentage of separate waste collection in Croatia, by province, for the year 2018[77]



Just as with the Netherlands, it should be noted for Croatia that population size, population density and the urban or rural nature of a county affect the ability of local authorities to ensure effective waste collection systems. Multiple studies have reflected on the different challenges that both urban and rural environments pose when it comes to waste collection.[78] However, the national and EU

76 Fond za zaštitu okoliša i energetsku učinkovitost (FZOEU), 'Smjernice za ponovnu uporabu u Republici Hrvatskoj' (Ente di Studio per la Pianificazione Ecosostenibile dei Rifiuti, 29 March 2016), p. 41.

77 Izvjesce o komunalnom otpadu 2018, pg 27.

78 Dijkgraaf and Gradus (2017), 503.

recycling targets are relevant for all regions, so there is value in looking at the various collection practices in different regions. The present research will do this for LSGUs in the Croatian county with the highest separate collection percentage (Međimruska Županija) and the county with the lowest separate collection percentage (Ličko-Senjska Županija).

In 2018 the county of Međimurje collected 6,186 tonnes of bio-waste, all of which was composted. At the time of writing, the latest available report on the implementation of the National Waste Management Plan and consolidated report of LSGUs was from 2020 about the previous year 2019.[79] The report is mainly focussed on summarising the relevant laws, reporting on the tonnage of waste collected by various local authorities in the county, as well as their success or failure to submit reports on their progress with their respective local waste management plans.[80] The report does stress the importance of separate collection and the underlying principles of the waste hierarchy in waste collection and treatment.[81]

Meanwhile, in 2018 the Ličko-Senjska County collected 213 tonnes of bio-waste, which were neither reprocessed or landfilled. Instead, all 213 tonnes were 'temporarily stored'. Temporary or long-term storage are relatively novel ideas. They refer to the storage of resources and materials for which there are currently no financially and/or technically feasible recycling options, but for which some feasible recycling options are expected in the near future (a decade or so). While the practice of long-term storage is legal, it is not widely applied for VFG storage. Long-term storage is discussed in more detail in the next chapter on sludge, for which it is applied more widely.

Local Self-Government Units / Local Authorities

Considering that local governments are largely responsible for actually carrying out waste management plans in Croatia, relevant legislation and policy plans are also reviewed. Article 64 of the national ZGO sets obligations for administrative bodies of local government, including the collection of municipal bio-waste in accordance with the priorities of the ZGO.[82] Collection must be done in a sustainable and cost-effective manner in accordance with the principles of sustainable development, environmental protection and waste management.[83]

The table below summarises the different legal and policy instruments that are, or could be, established by LSGU policies and waste collection plans. The research will look at the application of these instruments to the separate collection of bio-waste (in place of VFG) in the two provincial capitals and in two cities with a low population and low population density. The former are intended to be representatives of (slightly) more urban LSGUs, while the latter are intended

79 Međimurska Županija, 'Izvjesce o provedbi plana gospodarenja otpadom u Međimurksoj Županij', 2020.

80 Međimurksa Županija, 2020, 6-7.

81 Međimurksa Županija, 2020, 4, 8.

82 Law on Waste Management (ZGO) NN 84/2021, Article 64.

83 Ibid.

to be representatives of more rural LSGUs. For the Međimurska County, the county seat is Čakovec, with a population of 27,122.[84] While a more rural local government is that of Dekanovec, with a population of 739.[85] As for the Ličko-Senjska county, the provincial capital is Gospić, with a population of 11,502.[86] While a more rural local government is Lovinac, with a population of 943.[87] In comparison to the Dutch municipalities in these same categories, these are relatively small population sizes.

Interestingly, although Croatia's population is continually declining, there is a continued increase in the amount of waste produced in all local governance units – not just those in which the coverage of waste collection services has increased. Despite the fact that counties set the overarching waste collection targets, it is the LSGUs that actually develop waste collection plans in their respective areas and report their progress in achieving the goals of the plans. Waste collection plans and reports are the main documents, in addition to the LSGU website, from which information on the instruments each LSGU uses to encourage separate collection was drawn. A breakdown of the use of the various instruments by each LSGU is provided in Appendix 4, while a more general breakdown of the collective findings is provided here in Table 2 and the results below in boxes.

		Facilitating Conditions			Monetary Incentives		
		Information	Kerbside	Dropoff Points	Collection charges	Industry Subsidies	Penalties
M	Čakovec	2	2	1	2	0	2
	Dekanovec	1	1	1	0	0	2
LS	Gospić	0	0	0	0	0	1
	Lovinac	0	0	0	0	0	1

(Grading scale 0-2, where 0 indicates that the instrument is 'not used at all', 1 indicates that the instrument is 'used but not to its full potential' and 2 indicates that the instrument is 'used maximally').[88]

[84] Državni Zavod za Statistiku, 'Popis stanovništva, kućanstava i stanova 2021. – Stanovništvo – po gradovima/općinama' (Census, 2021).

[85] Ibid.

[86] Ibid.

[87] Ibid.

[88] Since the instruments are of a varied nature, there are different criteria for the numbered grades of each instrument. For example, for the instrument 'Information', a grade 1 is given if the municipality does offer some information on its website on how to separate waste, while a grade 2 is given if the municipality gives more extensive, easy to understand information (like instructions for separation by waste

Table 4: Policy instruments to encourage separate collection of VFG by local government units

Example 1: Findings for Čakovec

In Čakovec, the 2019 waste collection and disposal report was delivered on time, within the legal deadline, to the Međimurje county authorities.[89] The waste collection is done by the city's own utility company 'Čakom d.o.o.', which is responsible for all waste-related activities (including waste treatment and compost production) in Čakovec and two other LSGUs.[90]

Čakom d.o.o. collects waste from all legal and natural persons in the area, but the waste separation is done at the source by waste stream (mixed municipal waste, bio-waste, paper, plastic, metal and composite packaging).[91] Čakovec is also clearly the municipality applying the greatest variety of tools to encourage separate collection of VFG – including detailed information, kerbside collection, drop-off points, pay-as-you-throw and penalties for individuals for improper sorting.

Example 2: Findings for Dekanovec

In Dekanovec, the 2019 waste collection report was delivered to the Međimurje county authorities, but it was delivered later than the legal deadline. [92] The joint system for waste management in Dekanovec and eight other LSGUs is facilitated by the service provider 'PRE-KOM d.o.o'.[93] The service provider is owned mostly by the city of Prelog, which owns 87.5%. The remaining 12.5% is owned by the other 8 LGUs from the area of lower Međimurje, including Dekanovec.[94] Dekanovec was second best in the application of a variety of policy instruments, providing some information for citizens, some kerbside collection and drop-off points and having a complete system in place for penalties for households for improper sorting. It is the most lacking in monetary incentive policies, having no pay-as-you-throw scheme and no industry subsidies.

stream). In a further example, for the instrument 'Drop-off Points', a grade 1 is given if some drop-off points are offered throughout the municipal territory (however, they may be rare), while a grade 2 is given if the drop-off points for various waste streams are plentiful and located conveniently throughout many neighbourhoods of the municipal territory. Such a distinction between grade 1 and 2 can be made for all the instruments and is further clarified and elaborated upon below, when discussing the application of these instruments in each of the respective municipalities.

89 Međimurksa Županija, 2020, p. 7.

90 Međimurksa Županija, 2020, p. 5.

91 Ibid.

92 Međimurksa Županija (2020) 7.

93 Općina Dekanovec, 'Plan Gospodarenja Otpadom Općine Dekanovec' (February 2017), 11

94 Ibid, 11.

Example 3: Findings for Gospić

Gospić successfully delivered the 2019 waste collection report to the Ličko-Senjska county authorities.[95] In Gospić all waste management services are provided by 'Komunalac Gospić d.o.o'. There is no mention of bio-waste in the report, nor is there any mention of separate collection for any waste streams other than paper. Fout! Bladwijzer niet gedefinieerd. Of the researched policy measures, Gospić only put in place some penalties for households for improper sorting and seemingly makes use of no other measures.

Example 4: Findings for Lovinac

In Lovinac, the 2019 waste collection report was also successfully delivered to the Ličko-Senjska county authorities. The waste management in Lovinac is done entirely by the service provider 'Vrilo d.o.o', which is 100% under the ownership of the Lovinac LSGU.[96] While Lovinac does make reference to the national law requiring separate collection of different waste streams in its report, it is one of the LSGUs which has only recently started to implement this.[97]

In 2018 Lovinac was reported to have collected 0 tonnes of any separate waste stream (besides residual waste), while in their 2019 report they describe having collected 2 tonnes of paper, 1 of plastic, 2 of glass and 100 of textile waste.[98] Lovinac reports not having any insight into the tonnage of bio-waste discarded due to the prevalence of small-scale, home composting in the region. Of the researched policy measures, Lovinac only put in place some penalties for households for improper sorting and seemingly makes use of no other measures.

The Croatian LSGUs are struggling to make use of the various instruments at their disposal to encourage separate waste collection. A great emphasis is placed on educating the citizen population about waste separation at the source, but often there is little online information on how to go about this waste separation in the specific systems of the LSGU and few other facilitating conditions (or other instruments) put in place. With the exception of the Čakovec LSGU, which clearly views waste separation, collection and treatment as a top priority, the LSGUs are really struggling. The positive example of Čakovec demonstrated that perhaps the model for how Croatia could manage its waste does not need to come from another EU Member State, such as the Netherlands. Instead, it could come from within Croatia itself.

A report from the Croatian Agency for the Environment and Nature found that 'Croatia's national legislation in the field of waste management is continuously harmonised with changes in the EU regulatory framework, but

95 Ličko-Senjska Županija 'Plan o Provedbi Plana Gospodarenja Orpadom Republike Hrvatske' (May, 2019), 4.

96 Ličko-Senjska Županija (2019), 8.

97 Ličko-Senjska Županija (2019), 5.

98 Ličko-Senjska Županija (2019), 8-10.

implementation in practice is still in its infancy, which is confirmed by the fact that in 2017 only 22% of LSGUs separately collection bio-waste'.[99] At the LSGU level, all the attention (or 'blame') for insufficient separate collection of waste is put on the users of the waste collection services. The LSGUs claim it is the users who do not see waste as an issue, or are not willing to cooperate. Although this may be true to some extent, it is certainly not the only problem, and the LSGUs reflect only minimally on the role that improving waste collection systems through legislative or economic intervention could also benefit the situation. For example, relatively little attention is paid to improving access to drop-off points and to industry subsidies. Interestingly, compared to the Netherlands, Croatian LSGUs make much greater use of penalties for incorrect waste sorting.

In Croatia, the issue seems to be that many of the available instruments are not being implemented by LSGUs. A further, ever recurring issue is landfilling targets. If Croatia is not incinerating and reprocessing (and it is largely not) then it is mainly landfilling, which runs counter to EU waste management priorities. If Croatia were to prioritise effective waste reprocessing (and the necessary collection methods to facilitate it), perhaps it could skip the incineration step altogether – leapfrogging straight into a circular economy.

5.2 Treatment (Recycling, Recovery, Reprocessing)

As described in the general section above: VFG reprocessing offers a series of benefits through the conversion of 'waste' (often through composting) into a hygienic product, the diversion of landfills and the provision of valuable materials, as well as possible revenue.[100] Reprocessing helps prevent the loss of natural resources (both material and energy) that went into production, as well as helping avoid potential environmental harm (such as environmental pollution and greenhouse gas emissions) through the diversion of VFG from landfills. In the present research, the reprocessing of VFG has been divided into two stages to facilitate an easier overview of the relevant legislation and policy: requirements for reprocessing installations (minimum standards, permits and inspections) and requirements for products (input materials, end characteristics and labelling). The EU, Dutch and Croatian legal frameworks for both stages are discussed below.

99 The Croatian Agency for Environment and Nature is no longer active after a recent restructuring; however, their reports and findings remain relevant; Croatian Agency for Environment and Nature (2018) 7.

100 Lohri, Christian Riuji, Stefan Diener, Imanol Zabaleta, Adeline Mertenat and Christian Zurbrügg, 'Treatment technologies for urban solid biowaste to create value products: a review with focus on low- and middle-income settings' (2017) Reviews in Environmental Science and Bio/Technology 16(1): 81-130, 81.

When it comes to legislation at the EU level, all requirements for reprocessing installations (performing various treatment methods) are covered by the WFD or the Industrial Emissions Directive. We can recall that the various VFG treatment methods can loosely be grouped into biological treatments, physico-chemical treatments and thermo-chemical treatments. The two most common methods of bio-waste treatment in the EU are both biological treatments: composting and anaerobic digestion. Other relevant (upcoming) biological treatments are vermicomposting and black soldier fly treatment. The physico-chemical (pre)treatment most relevant for VFG is densification (after which the material is incinerated) while the most relevant thermo-chemical treatment is pyrolysis.

5.2.1 Waste Framework Directive

Article 3 of the WFD defines waste as 'any substance or object which the holder discards or intends or is required to discard' and 'waste management' as 'collection, transport, recovery (including sorting) and disposal of waste, including the supervision of such operations and the after-care of disposal sites and including actions taken as a dealer or broker'.[101]

Article 15 tasks the Member States with specifying the conditions for when responsibility over maximal recovery from waste is transferred from the original producer to any of the waste holders in the waste treatment chain. This is linked to Article 8 on extended producer responsibility (herein: EPR), because it leaves it up to the Member States to decide whether appropriate waste management is to be borne 'partly or wholly by the producer of the product from which the waste came'. There have yet to studies on EPR in relation to organic waste and VFG, only brief mentions in reports by the Ellen Macarthur Foundation that there are many other products and materials (including food waste) that require collection and management after use, and that EPR therefore could be applied to – once the concept is beyond its infancy.[102] We will look to national legislation on this topic to see how this responsibility is distributed in the Netherlands and Croatia.

Article 16 required Member States to have an integrated and adequate network of waste disposal and recovery installations for the recovery of mixed municipal waste collected from private households, but sub-clause 4 clarifies that this does not mean each Member State has to possess the full range of final recovery facilities within its borders. Such a requirement does not exist for VFG waste stream, even in Article 22, which specifically deals with bio-waste.

Articles 23 to 26 of the WFD set out the basic framework for permitting and registration, including what should be contained in a permit and the responsibilities of national competent authorities in relation to the issuing, exemption

[101] Waste Framework Directive [2018] Article 3(1) and Article 3(9).

[102] Ellen Macarthur Foundation, 'Extended Producer Responsibility, a necessary part of the solution to packaging waste and pollution' (Ellen Macarthur Foundation Website, 2021).

and extension of permits. Article 27 enables that the Commission shall adopt delegated acts supplementing the WFD, by setting out technical minimum standards for treatment activities (including for recycling of waste that requires a permit), but so far no such delegated acts have been published. What has been published and assessed by the Commission are the waste management plans that the Member States are required to submit to the Commission under Article 28. The plans, which are to be evaluated and reviewed by the Member States at least every six years, should reflect on types of waste collected on national territory, existing disposal and recovery installations, measures attained, general waste management policies (national and local) and can also discuss organisation aspects, instruments and programmes for waste prevention and public awareness campaigns.

When it comes to reporting and enforcement, the WFD only refers to required inspection, reporting, record-keeping, enforcement and penalties for uncontrolled management of waste as it relates to waste collectors and transporters. There is no mention of enforcement requirements for reprocessing installations that actually treat waste. This partially makes sense, as the legislation is aimed at limiting uncontrolled waste management, mainly as it relates to potential dumping and littering. However, there is room here for stronger requirements on inspection and reporting of treatment facilities, especially with respect to their respect of the waste hierarchy. Even if this was only a reporting requirement, it would help provide more insight into the reprocessing situation in Member States, which is currently lacking.

In addition to the WFD, the Industrial Emissions Directive is relevant when it comes to permitting and control of recycling installations.[103] The central aim of the Directive is to bring about rules on integrated prevention and control of pollution arising from industrial activities – and, where possible, to reduce emissions and prevent the generation of waste.[104] The directive applies to a variety of industrial activities, including waste management operations. Because biological treatment and physico-chemical treatment are listed in Annex 1, the Industrial Emission Directive applies to all the methods in these categories.[105] However, it only applies if the treatment installations are large enough. For example, the directive only applies to the disposal or recovery of waste in plants that have a capacity exceeding 3 tonnes per hour.[106] Waste plants that have a lower capacity are left purely under national legislative competence or under the WFD.[107]

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[103] European Parliament and Council Directive 2010/75/EU of 24 November 2010 on industrial emissions (Industrial Emissions Directive) [2010] OJ L334/17.

[104] Industrial Emissions Directive [2010] Art 1.

[105] Industrial Emissions Directive [2010] Annex 1.

[106] Industrial Emissions Directive [2010] Annex 1, Art. 5.2.

[107] L. Hermann and R. Hermann, 'Report on regulations governing anaerobic digesters and nutrient recovery and reuse in EU member states' (SYSTEMIC Project Publication, 2019).

5.2.2 Industrial Emissions Directive

Articles 4, 5, 6 and 8 of the IED first oblige Member States to ensure that no installation is operated without a permit and to ensure that permit conditions are continually complied with.[108] Article 14 goes on to set the permit conditions, which are mainly focussed on having installations respect emission limit values, monitor and report said values to relevant authorities and respect permit conditions set by conclusions in best available technique (herein: BAT) documents.[109]

In addition to permits, the control aspect of the directive is further developed through monitoring and reporting requirements, as well as the setting of penalties. Article 16 sets the monitoring requirements, which are also based on the BAT conclusions.[110] Meanwhile, Article 71 calls upon Member States to designate competent authorities, Article 72 sets the reporting requirements for Member States, and Article 79 ensures compliance by calling on Member States to determine the penalties applicable to infringements of the national provisions adopted pursuant to the Directive. Another form of control ensured by the Industrial Emissions Directive is public participation, in Article 24 (specifically regarding permitting) and Annex IV (on Public participation in decision-making). Public participation is, of course, ensured in accordance with the Åarhus Convention on access to information, public participation in decision-making and access to justice in environmental matters.

Plants and installations should also take into account the BAT standards and conclusions. The best available techniques or technologies are targets for industry practices, which develop and improve along with our societal values and technological advancements.[111] In the EU, the best available techniques for a variety of industrial sectors are described in BAT reference documents (Best Available Techniques Reference Documents, of BREFs).[112] The BAT are continuously referenced in the directive regarding requirements for the setup and maintenance of waste management installations.

Interestingly, Article 13 of the Industrial Emissions Directive also refers to the BAT reference documents in relation to information exchange. This article calls for the Commission to organise exchanges of information between Member States, the industries concerned, non-governmental organisations promoting environmental protection and the Commission itself in drawing up,

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108 Industrial Emissions Directive [2010] Art 4, 5, 6 and 8.

109 Industrial Emissions Directive [2010] Art 14.

110 Industrial Emissions Directive [2010] Art 16.

111 Industrial Emissions Directive [2010] rt 3(10); 'best available techniques' means the most effective and advanced stage in the development of activities and their methods of operation which indicates the practical suitability of particular techniques for providing the basis for emission limit values and other permit conditions designed to prevent and, where that is not practicable, to reduce emissions and the impact on the environment as a whole.

112 Industrial Emissions Directive [2010] Art 3(11).

reviewing and potentially also updating the BAT reference documents. Article 13 is particularly interesting in combination with Article 27, on emerging techniques, which calls for Member States and the Commissions to encourage the development and application of emerging techniques. These types of articles, which emphasise an evolution of technologies and an exchange of information on best practices (particularly in an environmental conservation context), are particularly important for industries that are in transition towards more circular functioning – as is the case with waste management.

Overall, the directive is interesting because of the balance it tries to strike between the integrated approach and relative flexibility. This approach is aligned with the proportionality principle in that it also aims to ensure that the content and form of Union action shall not exceed what is necessary to achieve the objectives of the Treaties.[113] According to the EU, the integrated approach means that an installation must take into account the whole environmental performance of its functioning (including emissions to air, water and land, generation of waste, use of raw materials, energy efficiency, noise, prevention of accidents and restoration of the site upon closure). This approach makes environmental conservation, sustainability and circularity core considerations in the setup and maintenance of industrial installations. However, the directive does allow some flexibility when it comes to this, because it allows competent authorities to set less strict emission limit values in specific cases where assessments show that achieving the BAT-required emission levels would lead to disproportionately higher costs compared to the environmental benefits.[114] This can be due to geographical location, local environmental conditions or technical characteristics of the installation. In any case, it ensures measures are proportional. There do need to be substantial grounds for such a derogation, but its existence nevertheless points to the balance the EU is trying to strike around the integrated approach.

As discussed in the general section of this chapter, there should be caution around the reprocessing treatment of VFG because a lot of non-renewable resources (energy and fertiliser to start) are applied in the production, processing and transport of vegetables and fruit, meaning that their overall production is neither entirely sustainable nor are they an entirely renewable resource.[115] This is why it is required that the net environmental benefit of VFG treatment reflects the resources and energy consumed in its production, collection, transport and reprocessing.[116] The aforementioned balancing between the integral approach and flexibility surrounding costs, in the Industrial Emissions Directive, seems to be an attempt to address concerns of this sort. This idea of 'sustainability balancing' is one of the central pillars of the IED, but it is not highly developed

113 Industrial Emissions Directive [2010] Preambulatory Clause 3.

114 Industrial Emissions Directive [2010] Art 15(4).

115 D. Pleissner, et al. 'Valorization of organic residues for the production of added value chemicals: A contribution to the bio-based economy.' Biochemical Engineering Journal 116 (2016): 5.

116 Environmental Services Association, 'Biowaste in a Circular Economy' (ESA UK Report, September 2014), 8.

in practice. There is especially little guidance on how to apply it in practice, with research demonstrating that national and municipal authorities seldom use their influence in this arena, and when they do it causes various problems.

The above requirements of the Industrial Emissions Directive are relevant to both biological treatment and physico-chemical treatment (as listed in Annex 1).[117] This means the directive could potentially apply to composting, vermicomposting, black soldier fly treatment and densification (if the treatment installations were large enough), although it does not explicitly mention them by name.[118] It is also highly unlikely that any BSF or vermicomposting treatment facilities would be large enough to fall under the IED in the near future. The biological treatment mentioned in the directive, once, is anaerobic digestion. Anaerobic digestion is mentioned in Article 5(3) of Annex 1 about capacities for recovery for non-hazardous waste: 'When the only waste treatment activity carried out is anaerobic digestion, the capacity threshold for this activity shall be 100 tonnes per day'.[119] The WFD also only briefly mentions both anaerobic digestion and composting. It mentions both in view of the importance of separate collection of bio-waste (Article 22) and in its list of recovery operations in Annex II. The WFD also does not mention physico-chemical treatments, such as densification. The combined analysis of the Industrial Emissions Directive and the WFD shows that there is relatively little method-specific legislation for re-reprocessing at the EU level.

Interestingly, since thermo-chemical treatments are not listed in Annex 1 of the Industrial Emissions Directive, it should be understood that the directive does not apply to waste management installations that recover materials from waste through pyrolysis (the thermo-chemical treatment method most relevant to VFG). However, the directive repeatedly mentions pyrolysis, but only in the context of incineration. Possibly due to the relative novelty of using pyrolysis to create char (which can be used as a soil conditioner), the directive only considers pyrolysis in its role as a method used in waste-to-energy.

However, newer EU policy documents and reports such as the 2020 EEA report on bio-waste treatment and the 2018 BAT documents do refer concretely refer to waste treatment methods going beyond biological treatment, including pyrolysis. The EEA report mentions pyrolysis in the segment on 'Innovation related to energy recovery from bio-waste', but it does refer to the non-energy products that can be recovered from waste treatment by pyrolysis, including high-value chemicals.[120] Furthermore, the BAT documents make continuous references to pyrolysis, although it is not always clear if this is in relation to energy or other products (such as soil conditioners and high-value chemicals).[121]

117 Industrial Emissions Directive [2010] Annex 1.

118 Industrial Emissions Directive [2010] Annex 1, Art. 5.2.

119 Industrial Emissions Directive [2010] Annex 1, Article 5(3).

120 European Environmental Agency, 'Bio-waste in Europe — turning challenges into opportunities' (EEA Website, 2020), 40.

121 2018 BAT documents, pp. 4, 490, 576, 712.

It should also be kept in mind that VFG is reprocessed at a non-industrial level, as well. In Croatia in 2017, it was reported that 65.028 composing units were distributed to households, although it is not clear how many of these were actively used, nor how much biodegradable material was composted using the units.[122] In the Netherlands in 2015, it was found that even without the presence of active promotion around household composting, around 5-10% of households were engaged in some form of home composting.[123] When it comes to EU legislation around composting, it only exists indirectly. The above-mentioned targets in the Landfill Directive require Member States to reduce the amount of landfilled biodegradable waste. This has resulted in 'a number of Member States including the promotion of home composting in their national strategies as a means to reach those targets'.[124]

A final important component of treatment is transport, governed by the Shipment of Waste Regulation. This regulation applies to WWTPs that would like to export their recovered products, which are labelled as waste for recycling across borders. The regulation states that a contract should be set up between the person responsible for the shipment of the waste and the receiver of the waste and that authorities from both the country of origin and the destination country need to authorize the shipment. This process is currently very time-consuming, at the same time as importing virgin resources of the same type does not have to undergo any such shipping process, making it easier to import the virgin raw material than the recovered materials contained in waste.[125]

Opening a Literal Can of Worms

The other two biological treatments, vermicomposting and black soldier fly treatment, were left for the end of this segment because they give rise to a host of other legal issues. As discussed above, in the general part of the chapter, vermicomposting systems are 'considered less energy consuming, more cost-effective and economically feasible when compared to conventional treatment technologies'.[126] Nevertheless, vermicomposting is not a widespread approach in waste treatment, largely because the product of vermicomposting is legally classified as animal manure and because worms simply do not consumer all types of waste. Products made from processing animal manure, such as compost resulting from vermicomposting, have to meet regulatory requirements for animal by-products. The heightened regulation around the use of animal by-products (herein: ABPs), comes from experience on how quickly ABPs can spread diseases and chemical contaminants, as well as the fact that as opposed

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[122] Croatian Agency for Environment and Nature (2018) 30.

[123] European Bioplastics, 'Home Composting Fact Sheet' (European Bioplastics Website, April 2015) 4.

[124] European Bioplastics (2015) p. 5; Report from the Commission to the Council and the European Parliament on the national strategies for the reduction of biodegradable waste going to landfills pursuant to article 5(1) of directive 1999/31/EC on the landfill of waste, COM/2005/0105.

[125] De Boer et al. (2018) 10-11.

[126] Lohri (2017) 92.

to composting there is no temperature gradient in vermicomposting, i.e. no hygienisation.

The 2009 EU Regulation on ABPs distinguish between three categories of animal by-products, identifying animal manure as a category 2 material.[127] The criteria of this Regulation can be seen as end-of-waste criteria for processed animal manure:

> Article 13(d and e)
>
> (d) used for the manufacturing of organic fertilisers or soil improvers to be placed on the market in accordance with Article 32 following processing by pressure sterilisation, when applicable, and permanent marking of the resulting material;
>
> (e) composted or transformed into biogas:
>
> (i) following processing by pressure sterilisation and permanent marking of the resulting material; or
>
> (ii) in the case of manure, digestive tract and its content, milk, milk-based products, colostrum, eggs and egg products which the competent authority does not consider to present a risk for the spread of any serious transmissible disease, following or without prior processing.

Although identified as less plausible than vermicomposting, the final biological treatment to be discussed here– black soldier fly treatment (herein: BSF treatment) – also remains an option. The EU has legal restrictions when it comes to feeding waste to insects. Annex III of another 2009 regulation, on the placement on the market and use of feed, prohibits the use of faeces and separated digestive tract content for insect production.[128] In addition to this the ABPs regulation considers insects as 'farmed animals' and thus does not allow manure, catering waste or former foodstuff that may contain meat and fish as feed. The European Commission is aware of the need to provide wiggle room in this area to facilitate use of alternative reprocessing methods; however, before taking concrete steps in this direction, there is still research being done by regulatory bodies on biosafety, hazardous contaminants and allergens.[129] In addition to policies that outright block waste reprocessing methods like BSF treatment, there is also an issue with a lack of favouring policies, which would encourage businesses to explore these types of options (once the other legal barriers are removed).

[127] Regulation 1069/2009/EC of the 21st October 2009 laying down health rules as regards animal by-products and derived products not intended for human consumption (Animal By-Products Regulation, 2009) [2009] OJ L300/1., Art. 9.

[128] European Parliament and Council Regulation 767/2009/EC of the 13 July 2009 on the placing on the market and use of feed [2009] OJ L229/1, Annex III.

[129] Lohri (2017) 95; EFSA Scientific Committee (2015) Risk profile related to production and consumption of insects as food and feed. EFSA J 13(10):4257.

According to the EU Animal By-Products Regulation (EC 1069/2009) all installations that store or process animal by-products must have both an environmental permit and an approval for operations with animal by-products and/or derived products, issued by the national competent authority.[130] In the Netherlands, the Ministry of Agriculture, Nature and Food Quality (LNV) is the competent authority for issuing and checking these approvals. On behalf of the LNV, the NVWA checks that the installations are in compliance with both EU and national regulations and issues the necessary approval.[131] In Croatia, the competent authority for permitting and control of animal by-product installations is also the Ministry of Agriculture.[132] Croatian law also requires the permitting and registry of installations that process animal by-products, as well as entities transport and make products out of animal by-products. This is in compliance with EU law, but has been part of the Croatian legislative framework since before it joined the EU, as well.[133]

As per Annex V of EU regulations No 142/2011, it is permitted to convert certain animal by-products (listed in the Annex) into biogas or compost if certain parameters are respected.[134] These are parameters such as temperature of materials during treatment, duration of treatment, bacteria levels in samples following treatment etc. In the Netherlands, it is possible for the NVWA to also recognise and approve a reprocessing method that does not meet the parameters described in the 2011 Regulation, so long as a successful validation of the process is carried out and the reprocessing method is guaranteed to be safe. Composting at home is also permitted in spite of these regulations, as long as it is not transported or sold.

Dutch reports on this topic have explained that 'Hygienising the material is not enough', and both national and EU regulations set all kinds of requirements for the handling of the entire installation and the incoming and outgoing flows.[135] This includes the degree of particle size reduction, whether the heating is natural or forced, the duration of the process and the measurement, registration and monitoring of temperature and time. In addition, 'other aspects are considered, such as the registration of incoming and outgoing material, the location and method of storage of imports and exports, measures against vermin, and so forth'.[136] If a technique proves itself in practice through this

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130 Commission Regulation (EU) No 142/2011 of 25 February 2011 implementing Regulation (EC) No 1069/2009 of the European Parliament and of the Council laying down health rules as regards animal by-products and derived products not intended for human consumption, EC 1069/2009 (Animal By-Products Regulation 2011), Article 24 (1,2).

131 LAP3, Sectorplan 06, p. 6.

132 Croatian Agency for Environment and Nature (2018) 20.

133 Pravilnik o registraciji subjekata i odobravanju objekata u kojima posluju subjekti u poslovanju s nusproizvodima životinjskog podrijetla (20/10).

134 Animal By-Products Regulation (2011), Annex V, Chapter III, Section 2 and 3.

135 LeAF Report (2020) 8-10.

136 LeAF Report (2020) 8-10.

validation, parameters for the reprocessing method can be included in national legislation.[137] The increased interest around these new methods is promising with so many new methods on the rise, such as vermicomposting and BSF treatment.

In Croatia, there is less legislation on animal by-products that goes beyond that at the EU level. Since Croatia's entry into the EU, the direct transposition of EU regulations into Croatian national law has been a top priority, and this has included the EU's by-products regulation.[138] According to the relevant EU legislation, a national competent authority can authorise exceptions to the use of animal by-products for special purposes, such as research,[139] food-related purposes[140] and certain cases of by-product collection, transport and disposal.[141] The Croatian Food and Veterinary Office (HR: Ured za hranu) supports these conclusions, but also points to the need for improvements in terms of traceability of by-product flows and the effectiveness and harmonisation of official controls.[142]

5.2.3 Dutch Requirements for Installations

At the national level, most attention around the reprocessing of VFG is geared towards reprocessing of VFG for agricultural application (mainly as compost to be used as fertiliser).[143] The primary focus of this section is on treatments for compost. However, the other biological treatments (bokashi, vermicomposting and BSF treatment), alongside the physico-chemical and thermo-chemical treatments, are also addressed.

In the Dutch legislative landscape, the most relevant legislation and policy for reprocessing installations are the LAP3, the Environmental Management Act (in Dutch: Wet milieubeheer, Wm) and the General Provisions Environmental Law Act (Dutch: Wet algemene bepalingen omgevingsrecht, herein: Wabo).[144] Seeing as this research was 'closed' on the 1st of July 2023 it does not cover the forthcoming transition to the Dutch environmental and planning law, since it was not certain if the law would come into force before the manuscript was completed (scheduled to be introduced on the 1st of January 2024). In general, this change to the Dutch legal framework does not imply major changes to the content of the present research, particularly not the conclusions. The Wm is relevant because it is the implementing legislation for the European WFD.

137 LeAF Report (2020) 8-10.

138 Pravilnik o nusproizvodima životinjskog podrijetla koji nisu za prehranu ljudi (87/09).

139 Animal By-Products Regulation (2009) Article 17.

140 Animal By-Products Regulation (2009) Article 18.

141 Animal By-Products Regulation, (2009) Article 19.

142 Vlatka Tomašić, 'Novosti u propisima koji reguliraju postupanje s nusproizvodima životinjskog podrijetla koji nisu za prehranu ljudi' (Veterinarski Institut Website, 2020).

143 LeAF Report (2020) 18, i-ii.

144 Implementing Decree Fertilizers Act 2005 (Dutch: Uitvoeringsbesluit Meststoffenwet, UBMW).

Specifically regarding new installations, the Wm sets the environmental protection requirements and puts limitations on environmental hindrances of installations – like noise, light and odour.

The Wm, being primarily an environmental act, frames the issue of waste entirely in an environmental context. As such, matters like responsibility over waste (Article 15 of the WFD) are viewed entirely from that context. Article 10(3,4), for example, views all waste holders at any stage of the waste management as responsible for any adverse consequences for the environment as a result of uncontrolled waste, rather than the original waste 'producers'. The same is true at the EU level, where there is no extended producer responsibility for organic waste. EPR schemes in the NL exist for five categories of products: Electrical and electronic equipment; Batteries and accumulators; Scrap vehicles; Car tyres; and Packaging.

When it comes to permitting, Dutch law is in compliance with WFD's requirements.[145] Previous reports on this topic have identified that a major concern in the Dutch reprocessing system is that 'when striving to contribute to circularity, it is possible that risks are underestimated, or that not all aspects of the processing are properly analysed'.[146] As such, it is up to the competent authority to make a proper assessment before granting a permit for waste reprocessing installations (and this is before we even get into the products of this reprocessing and the placing of those product onto agricultural land). The authority that has the competence to grant a permit is dependent on the type of activities that are to be carried out at the installation, and this is not regulated in the Wm, but rather in the Wabo. According to Article 2 of the Wabo, the permit requirement applies to all projects that consist wholly or partly of founding, changing or altering a facility's operation.[147] Most waste reprocessing operations therefore require an environmental permit (Dutch: omgevingsvergunning). Regarding the competent authority, the basic rule is that the competent authority is the municipality (Dutch: burgemeester en wethouders);[148] however, for some activities, the province or the minister can be the competent authority.[149] The province is the competent authority on projects deemed to be 'of provincial importance', whereas the minister has competence on projects deemed to be of 'national importance'. It seems that this type of executive discretion at each level is suitable for ensuring that proportional measures are put in place and enforced when it comes to balancing the objectives needed.

These requirements of the Wabo are implemented by the Environmental Law Decree (Dutch: 'Besluit omgevingsrecht'), in which we can find exactly to which installation activities the environmental permits apply. Annex 1 (Part C and B) of this Environmental Law Decree indicates that establishments that work with

145 Wm, Article 13.2 11.

146 LeAF Report (2020) iii.

147 Dutch General provisions act (Wabo), Article 2.1(e).

148 Dutch General provisions act (Wabo), Article 2.4(1).

149 Dutch General provisions act (Wabo), Article 2.4(2, 4).

biomass[150] do require an environmental permit and that the competent authority is not the municipality.[151] The general methods are listed in Annex I, Part C of this decree.

If a treatment method or installation is mentioned in the EU Industrial Emissions Directive, then the competent authority is the province, not the municipality, while if it is not mentioned, then the competent authority is the municipality.[152] Recovery installations for both biological treatments and physico-chemical treatments of non-hazardous waste are mentioned in the IED (provided that the installations exceed a capacity of 75 tonnes per day), meaning that the province is the competent authority for these installations.[153] Composting and anaerobic digestion installations definitely meet this capacity, as the Netherlands treats a total of around 1,763,000 tonnes of VFG per year, with even the smallest installations treating more than 29523 tonnes per year (around 80 tonnes per day).[154] However, most installations treat much more. Vermicomposting and black soldier fly treatment installations, on the other hand, are nowhere near the 75 tonnes per day capacity, so for them the municipality would be the competent authority. Thermo-chemical treatments are not mentioned as a whole category in the IED, and pyrolysis is only mentioned in the context of incineration, so recovery plans that use pyrolysis as part of the recovery process would have the municipality as the competent authority.

In addition to the permits required by the provincial authorities, there are also requirements for processing at the national level. As discussed above in the EU law segment, a concern is that EU reuse and recycling targets do not distinguish between various recovery processes, meaning that resource efficient and environmentally safe recovery does not have to be given priority.[155] For Member States wanting to ensure their reprocessing is as environmentally friendly and circular as possible, standards more relevant to these types of goals have to be implemented at the national level. In the Netherlands, one of the examples of these types of standards is the 'minimum standard for processing' which is set

150 Biomass here includes: A) products consisting of vegetable agricultural or forestry material that can be used as a fuel to exploit its energetic content; B) the following wastes:

1. vegetable waste from agriculture or forestry

2. vegetable waste from the food industry, if the generated heat is recovered

3. fibrous vegetable waste from the production of raw pulp and from the production of paper from pulp, if it is co-incinerated on the production site and the heat generated is recovered

4. cork waste

5. wood waste, with the exception of wood waste that may contain halogenated organic compounds or heavy metals as a result of treatment with wood preservatives or by applying a protective layer.

151 Environmental Law Decree (Dutch: 'Besluit omgevingsrecht'), Annex 1 (Part A and C).

152 Activiteitenbesluit milieubeheer, Section 2.2.

153 Industrial Emissions Directive [2010] Annex I, Clause 5 'Waste Management'.

154 This ends up being around 80 tons per day (29523/365); Rijkwaterstaat's Afval monitor.

155 Arm et al. (2017) 1491.

out in the LAP3, a policy document.[156] These requirements set the minimum required quality of reprocessing for each respective waste stream. These standards exist to prevent waste reprocessing at a lower-than-desirable level, in accordance with the EU waste hierarchy. For example, if the minimum standard for a waste stream is recycling, then that waste stream cannot be incinerated. For VFG stream, the same minimum standard applies to both separately-collected VFG from households and industry. The minimum standards are composting with the aim of recycling or fermentation using the formed biogas as fuel.[157] T, The LAP further provides a link to the BAT standards, to ensure best practices in relation to waste management and efficient use of natural resources in industrial sectors.[158]

When it comes to enforcement, the authority that permits installations is also the authority that controls and enforces the requirements. Controls include periodic monitoring to ensure compliance with BAT standard and environmental inspections to examine the full range of relevant environmental effects from the installations.[159]

The reprocessing of VFG into products higher up on the bio-based value pyramid (and more in line with the waste hierarchy) can be stimulated through subsidies for industry.[160] In the Netherlands, there are more support schemes for industry actors that re-process waste into biogas;[161] however, there are some subsidies relevant for nutrient recovery as well. For example, the 'MIA' and 'Vamil' schemes offer a fiscal advantage to enterprises investing in environmentally friendly equipment (deduction from investment costs and early deprecation).[162] What is and is not 'environmentally friendly equipment' is determined by an 'Environmental List',[163] which is subject to annual review and contains equipment aimed at resource conservation, waste prevention, reuse, recycling or environmentally friendly waste management.[164] The list is

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156 LAP3, Sectorplan 06; Gescheiden ingezameld/afgegeven groente-, fruit- en tuinafval van huishoudens, p. 1, Art II.

157 Ibid.

158 LAP3 Beleidskader, A.6.2.1.1.

159 IED, Article 16 and Article 23.

160 See Section 1.4 of the Introduction Chapter (Chapter 1).

161 Hermann and Hermann (2019); an example is the Subsidy Scheme for sustainable energy production ('Stimulering Duurzame Energieproductie'SDE), which 'compensates the difference in production costs between fossil and sustainable energy'. It is available for energy from waste incineration and biogas from the digestion of organic waste. For energy from organic waste the basic subsidy amount is EUR 0.12 per kWh.

162 Netherlands Enterprise Agency, 'MIA and Vamil' (RVO Website, December 2022a); Frans H. Oosterhuis, Heleen Bartelings LEI and Vincent GM Linderhof LEI, 'Economic instruments and waste policies in the Netherlands' (Report for Ministry of Housing, Physical Planning and the Environment, 2009), p. 76.

163 Netherlands Enterprise Agency (2022a).

164 Oosterhuis, Bartelings and Linderhof, (2009), 76-77.

created by the Netherlands Enterprise Agency (RVO) and commissioned by the Ministry of Infrastructure and Water Management. Equipment currently listed includes both 'Production equipment for raw materials or products made from biomass'[165] and 'Production equipment for (products of) bio-based plastics'[166] – among others also relevant for VFG reprocessing and resulting products.

An example of subsidies that could incentivise more recovery from VFG can be found in the Netherlands, where the government provided financial support for the full-scale implementation of the nutrient recovery and recycling at a bio refinery run by Groot Zevert Vergisting B.V. (GZV), turning digestate into separated phosphate, and nitrogen and potassium fertilisers, potting soil and clean water.[167] The existence of these types of projects demonstrates that there are opportunities for mutually beneficial collaborations between public and private actors in the sphere of recovery from waste, ones that could be replicated for VFG.

5.2.4 Croatian Requirements for Reprocessing Installations

Croatian national law surrounding reprocessing and installations is continually updated to comply with the EU regulatory framework. The most important national legislation in this area is the ZGO, its implementing by-laws and the 2017-2022 National Waste Management Plan (Herein: PGO; HR: Plan gospodarenja otpadom Republike Hrvatske za razdoblje od 2017 do 2022).[168] The updated plan for the years 2023-2028 is still awaited.

In addition to requiring separate collection of bio-waste, the ZGO specifically references that such collection is to be done with the aim of composting, digestion and energy recovery, to meet a high level of environmental protection. The law places a specific emphasis on energy recovery and does not explicitly mention recovery of other valuable materials like nutrients, although it does explicitly mention bio-plastic (which is one of the possible products of nutrient recovery).[169]

In order to realise both the desired high level of environmental protection and the 40% separate collection target (discussed in the Collection segment), Croatia's PGO prescribes measures to facilitate better reprocessing. These include a call for the development of quality criteria for reprocessed materials (compost and digestate); methods of labelling and quality control for said materials; and increasing the capacity and technology of existing plants for biological treatment of separately-collected bio-waste by aerobic or anaerobic processes.

[165] Netherlands Enterprise Agency (RVO), 'Productieapparatuur voor grondstoffen of producten op basis van biomassa' (RVO, 26 December 2022b).

[166] Ibid.

[167] Hermann and Hermann (2019), 76.

[168] Croatian Agency for Environment and Nature (2018) 7.

[169] Law on Waste Management (ZGO) NN 84/2021, 4.4; Bio-plastic is mentioned but only as a definition in Article 4.4, not in any of the substantive clauses.

Article 12.3 of the PGO established a timeline for the implementation of these measures, claiming that the quality criteria for compost and digestate made from bio-waste should have been completed in 2018, that the 'equipment' for the separate collection of bio-waste should have been completed in 2020 and that the construction and improvement of installations for the biological treatment of bio-waste should have been completed in 2020. These measures were implemented to increase the overall national, planned composting capacity to 200,000 tonnes a year.[170] There is no publicly available documentation online that would indicate that either of these deadlines has been met.

A final piece of national legislation relevant to reprocessing is the Ordinance on Thermal Treatment of Waste (Pravilnik o termičkoj obradi otpada, NN 75/2016). This Ordinance transposes the IED into national law, most relevantly the requirements on permitting and control of reprocessing installations. Obviously, the same permitting requirements that trickle down from the EU level, the IED specifically, to the Netherlands, apply in Croatia as well. As already discussed in the segment on Dutch reprocessing legislation, according to Annex I of the IED, if a treatment method or installation is mentioned in the IED, the competent authority is the national province, not the municipality, while if it is not mentioned, the competent authority is the municipality. The Croatian equivalent of provincial authorities are the regional authorities (counties) and the equivalent of municipal authorities are the local self-government units (LSGUs). Since recovery installations for both biological treatments and physico-chemical treatments of non-hazardous waste are mentioned in the IED (provided that the installations exceed a capacity of 75 tonnes per day), we know that the Croatian regional authorities (the counties) would be the competent authority for these installations.

Croatia treats much less VFG than the Netherlands. Croatia produces around 580,000 tonnes of VFG per year and separately collects only 11% of that, so around 60,000 tonnes per year (164 tonnes per day). Even if we assume that all of this is treated (which it is not), it is nearly impossible for the average treatment installation to meet the 75-tonne requirement for the IED to apply, meaning that for most installations the LSGUs would be the competent authority (unless otherwise specified by national law.

When it comes to competent authorities, Article 10 of the national ZGO is clear that the national government and the MINGOR are responsible for prescribing waste management measures. Meanwhile, the Fund for Environmental Protection and Energy Efficiency (herein: FZOEU) is the implementing body at the state level. At the regional and local level, the local and regional self-government units are responsible for ensuring the conditions and implementation of the prescribed waste measures. Article 10(5) states that each local self-government unit does not have to be responsible for its waste independently, but that it is possible (by mutual agreement) to ensure the joint implementation of prescribed waste management measures between several

[170] Croatian Agency for Environment and Nature (2018) 28.

LSGUs. Although it seems that executive discretion is properly regulated in Croatia, there is stagnation in practise and questions arise around whether the executive bodies fully carry out their discretionary powers when it comes to the achievement of environmental and circular objectives.

Waste treatment (including reprocessing) is carried out at Waste Treatment Centres (HR: Centar za gospodarenje otpadom), which are owned by government-funded trading companies (HR: trgovačko društvo).[171] The LSGU executive bodies are obliged to ensure that the public service provider responsible for waste collection delivers the waste to the appropriate waste treatment centre, and the LSGU enters into an agreement with the relevant trading company that will execute the collection and treatment of municipal waste.[172] Meanwhile, the trading company which manages the centre is obliged to receive all municipal waste from the public service provider and apply a set price of processing per ton, in accordance with the National Waste Management Plan.[173]

The Waste Treatment Centres are not to be confused with 'Centres for Reuse' (HR: Centar za Ponovnu Uporabu), which are a relatively new addition to Croatia's waste management framework. Centres for reuse are defined as 'establishments in which reuse operations are carried out', meaning that they are usually business entities that collect materials, objects and other goods with the intention to reuse them before they acquire waste status, or (if legal requirements are met) reuse them following the achievement of end-of-waste status. 'De-categorisation' is defined in Article 4(7) of the ZGO,[174] while its Article 16 gives Reuse Centres the right to de-categorise waste materials. Organic materials and VFG are not listed among the waste streams that can be de-categorised.

This leads us into the important component: permitting requirements. Legal persons and entities can obtain a permit for waste management (including recovery) that typically last ten years, from either the national authority or the regional authority (the county).[175] The national authority issues permits for waste management activities that include hazardous materials (Procedures R1) and for waste that is mainly used as fuel or for other means of obtaining energy (Procedures D10, incineration of waste on land).[176] The regional authorities issue permits for all other waste management activities, which then also include reprocessing of streams like VFG.[177] All entities that obtain a permit, be it nationally or regionally, are entered into the online register. A record of

171 Law on Waste Management (ZGO) NN 84/2021, Article 13.

172 Law on Waste Management (ZGO) NN 84/2021, Article 13(2).

173 Law on Waste Management (ZGO) NN 84/2021, Article 13(3).

174 Decategorisation is the process by which a re-use centre can designate end-of-waste status (and give product status) to a certain quantity and type of material/good; Law on Waste Management (ZGO), Article 4(7).

175 Law on Waste Management (ZGO) NN 84/2021, Article 30, 32.

176 Law on Waste Management (ZGO) NN 84/2021, Article 302(1).

177 Law on Waste Management (ZGO) NN 84/2021, Article 302(2).

waste management permit holders is publicly available on the website of the MINGOR.[178]

In terms of control and enforcement, the first element is reporting and monitoring for compliance with national and EU standards. The collection of data on bio-waste is currently defined through several directives at the EU level and transposed into Croatian national legislation.[179] The majority of Croatia's bio-waste data is collected in e-ONTO, the Information System for Waste Management (discussed in the collection segment above). A small part of the data, specifically that on facilities processing animal by-products, is collected by the Ministry of Agriculture.[180]

Data on bio-waste reprocessing is tracked until the point where it achieves end-of-waste status. We have data on how much waste is collected all together, how much of each stream is collected, where it is transported, how much it costs, how much is reprocessed, etc, but we do not have any data on what happens to the materials once they become a product again. It is not required by either the national or EU legal framework that this data be collected, so we do not know where this waste goes once it becomes a product again, nor do we know what it is used for (if it is used at all). This is worrisome because it means we cannot follow the feedback loop following reprocessing, to see to what degree the cycle is closed and the materials are returned into the economy. It is possible that some portion of these products is still landfilled or used inappropriately, thereby undermining the basis of the circular economy concept.

The final components of control and enforcement are inspections and penalties. Inspections are carried out by different authorities at different stages of the life cycles of waste materials. There are no specific inspections for VFG or bio-waste, but the general rules for waste inspection are outlined in Articles 136 and 137 of the ZGO.[181]

Additionally, the articles of Title XVI, which address inspections, focus a great deal on the mining industry, waste trade, improper landfilling and collection. Although there are articles that touch on the ability of inspection authorities to inspect installations and require documentation for 'improper waste management', there is relatively little guidance on inspections of reprocessing installations specifically. There is also no specific mention of inspections of waste installations that treat bio-waste, or waste installations that treat waste that is intended for reuse or recovery.

Penalties for improper waste management are issued for a wide variety of reasons, discussed at length in Title XVII of the ZGO. Penalties can be handed out for anything from failure to register reuse installations in the national system, to failure to report quantities of waste produced/collected/treated/

178 Law on Waste Management (ZGO) NN 84/2021, Article 29(9); V. Petrović, 'Centri za ponovnu uporabu' (Kruzna Ekonomija Website, 22 May 2017b).

179 Croatian Agency for Environment and Nature (2018) 20.

180 Ibid.

181 Law on Waste Management (ZGO) NN 84/2021, Article 136-137.

stored/landfilled, to failure to appropriately respect deadlines and documentation requirements for permit extensions.[182] The ZGO also provides as possibility of a high financial penalty when a waste producer or waste holder failed to treat waste for reprocessing, if such treatment *was possible*.[183] Although it is sure to be a headache in many cases to prove in court that treatment for reprocessing 'was possible', it is quite forward thinking to provide a legal basis for failure to modify treatment operations to be as in line with the EU waste hierarchy, when such treatment is possible.

Although some preliminary steps have been taken to ensure bio-waste reprocessing, the remaining potential for reprocessing bio-waste from municipal waste remains at an extremely high 91%, signalling that there is a lot more work to be done.[184] The legislative gaps that exist could be filled in an effort to lower this percentage. This effort could include a series of incentives, some of which have already been discussed in reports written by the FZOEU (i.e. financial benefits for waste processors). The penalties discussed above are clearly examples of 'negative incentives', but the FZOEU report also discusses some possible positive incentives.

As pointed out, revenues from the sale of goods and materials alone are often insufficient for sustainable business, so there is a need to look to models through which reuse can be financially stimulated (financial instruments). There are five financial instruments that can help stimulate the sector in Croatia:

1. Financial incentive at the national level (from the extended responsibility system);
    - This is codified in the ZGO, but as mentioned previously is applied only to electronics and is not yet even conceived of as something that can be applied to organic materials;[185]
2. Financial disincentives at the national level – taxes and fees for waste landfilling;
3. Incentive revenues at the local level;
4. Subsidies for the employment of hard-to-employ groups.
    - According to a report by the FZOEU, 'the social character of the reuse sector is mainly emphasised in the employment of people from hard-to-employ groups, such as the long-term unemployed, young people without experience, the elderly, people with lower education, unskilled workers, people of lower socioeconomic status and people with disabilities, special needs and the like'.[186]
5. European Social Fund;
    - The EU's main financial instrument for achieving strategic

[182] Law on Waste Management (ZGO) NN 84/2021, Article 165(6).

[183] Law on Waste Management (ZGO) NN 84/2021, Article 167(8-9).

[184] Croatian Agency for Environment and Nature (2018) 47.

[185] Fond za zaštitu okoliša i energetsku učinkovitost (FZOEU), 'Smjernice za ponovnu uporabu u Republici Hrvatskoj' (Ente di Studio per la Pianificazione Ecosostenibile dei Rifiuti, 29 March 2016) 41.

[186] Fond za zaštitu okoliša i energetsku učinkovitost (2016) 41.

> employment policy objectives. One of the important measures is to finance the strengthening of administrative capacity in the state administration and the public sector in the field of economy, employment, social policy, environment and justice.

The last two of these financial instruments, but particularly the fourth, demonstrate the wide scope of a circular economy and the interconnectedness of the various topics it touches. Subsidies for a social benefit (i.e. aid in employing hard-to-employ groups) are not likely to impact waste actors' ability to obtain funds to be used to make environmental and technological strides in treatment processes.

5.3 Recycled Products from VFG Waste

As discussed in Section 1.1.5 of the present chapter, the reprocessing of VFG can result in three types of products to close the material loop. These are fertiliser products, platform chemicals (bioplastics) and bio-energy (with bio-energy having been excluded from the scope). The legal requirements around fertilisers and bioplastics are discussed here.

For materials, such as VFG, which are defined as waste in some phase of their life cycle, the end-of-waste criteria of the EU are an important stepping stone to reuse them as different products. As explained in the Introduction to this thesis,[187] the definition of waste in the EU is linked to the act of discarding a material.[188] This definition is important in the context of environmental protection (against contamination from discarded materials), but it has proven to be a barrier to circularity. Due to the necessity for materials within the circular economy to only temporarily be labelled as waste (before being re-introduced into the economy as products), the 'end-of-waste' status was developed. The end-of-waste criteria were formulated in Article 6(1) of the 2008 revisions of the WFD and were not changed in the 2018 consolidation. According to the criteria product status can be achieved under the following four criteria:[189]

- the substance or object is to be used for specific purposes;
- a market or demand exists for such a substance or object;
- the substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products; and
- the use of the substance or object will not lead to overall adverse environmental or human health impacts.

[187] See Section 1.1 'The Waste Challenge' of the Introduction Chapter (Chapter 1).

[188] Waste Framework Directive [2018] Art. 3(1).

[189] Waste Framework Directive [2018] Art. 6.

The original intention was that these criteria would be expanded upon for each waste stream, but at the moment only three exist, for: iron scrap, copper scrap and glass cullet.[190]

The EU Joint Research Centre has developed criteria for several other waste types (including compost), but these have not been included in the WFD because of a lack of agreement on the criteria from Member States.[191] Different Member States put varying levels of emphasis on the issue of end-of-waste, partly because of the varying accessibility of virgin materials and partly because of the differences in perception around acceptable risk level when it comes to reintroducing end-of-waste materials as products. Further expansion and implementation of end-of-waste rests with Member States, many of which have further decentralised the issue to local authorities.[192]

Obtaining End-of-Waste Status

The first step to obtaining end-of-waste status is to check whether end-of-waste criteria for the specific material are available at the European or national level. As mentioned above, European criteria only exist for iron scrap, copper scrap and glass cullet.[193] At the national level, the relevant ministry (usually the ministry for the environment) has the authority to draw up end-of-waste criteria for the materials not addressed at the EU level. There is only one such piece of ministerial legislation in the two case-study Member States relevant to the present research, and that is the Dutch Regulation on recycling granulate (Regeling vaststelling van de status einde-afval van recyclinggranulaat; Ministerie van Infrastructuur en Milieu, 2015).

At both the European and national levels, the end-of-waste criteria must describe the exact input and end-requirements that need to be met by materials in order to achieve end-of-waste status. When the material-specific criteria and the four conditions from Article 6(1) of the WFD are met, the material is no longer considered waste (i.e. it has a product status). Once product status is obtained, rules applied to the materials when they were deemed to be waste (the obligation to report specific characteristics, transport movements, holders, etc) are no longer applicable.

The end-of-waste status obtained is only valid for materials in a specific product location, with specific application(s) and customers. For example, when the manufacturer of materials that received end-of-waste status decides to apply these materials differently than what is declared in the initial self-declaration, the manufacturer needs to re-apply to demonstrate that the end-of-waste criteria

190 N. Johansson, & C. Forsgren, 'Is this the end of end-of-waste? Uncovering the space between waste and products. Resources, Conservation and Recycling' (2020) 155.

191 Johansson & Forsgren (2020), 1.

192 Waste Framework Directive [2018] Art. 6(3-4).

193 Johansson & Forsgren (2020), 1.

are still met.[194] In the Netherlands, confirmation that the criteria are still met in the re-application comes through a legal opinion by the State Secretary of the relevant ministry, but this document has no legal status.[195] This is because the monitoring and possible decision-making about the holder's evidence is decentralised, resting with the relevant competent authority (usually the municipality) when it comes to permitting, inspection and enforcement.[196]

Croatia's end-of-waste framework is done through copy-paste implementation of the EU legislation, meaning that there are no additional criteria for specific streams beyond what is transposed from the EU. The EU legislation is transposed into Croatian legislation via the 'Law on Waste Management' (herein: ZGO, HR: *Zakona o gospodarenju otpadom* NN 84/21) and the 'Ordinance on by-products and revocation of waste status' (HR: Pravilnik o nusproizvodima i ukidanju statusa otpada, NN 117/2014). The status of waste may be revoked for certain waste materials if it is entered in the 'Register of Waste Status Revocation', submissions to which are subject to an approved by MINGOR.[197]

Critiques of End-of-Waste

One of the issues with the WFD when it comes to end-of-waste, in addition to the lag in development of criteria for different waste streams, is that, in order to achieve product status, there must already be a functioning 'market or demand' for the relevant substance.[198] Scholars have pointed out that end-of-waste status therefore has little to no effect on improving circularity, because according to the WFD, only waste that is already being treated for recovery, and is already sought after, can cease to be waste. As explained by Johansson & Forsgren in 2020: 'the end-of-waste legislation has only reduced the administrative burden by avoiding waste legislation, rather than trigger[ing] circulation of waste that was previously not recovered'.[199]

Johansson & Forsgren go on to point out that product legislation that is relevant for waste that has achieved product status, such as REACH, can often be difficult for secondary resources to abide by (because it is more difficult to trace the materials in secondary products than in primary products). This means that despite the existence of legislation for end-of-waste status, its current state does little to drive the circular transition forward. This is especially the case in waste streams that are considered more 'high risk', such as VFG and sludge. Another

194 Emmeken van den Dungen & Laura van Schöll 'Assen en de Wet [Ashes and the Law]' (Nutrient Platform NL, Report, 1 March 2022), 3-4.

195 A legal opinion is not a decision within the meaning of the Dutch General Administrative Law Act (the GALA). It is possible that another competent authority would not judge the facts in the same way, leading to issues with legal certainty in the follow-up for end-of-waste criteria and decision making.

196 van den Dungen & van Schöll (March 2022), 4.

197 Law on Waste Management (ZGO) NN 84/2021, Article 44 and 45.

198 Waste Framework Directive [2018] Art 6 (1(b)).

199 Johansson & Forsgren (2020), 1.

difficulty with end-of-waste is that it is decided on a case-by-case basis, leading to much confusion among industry actors.[200] This is evident even in cases before the CJEU, such as Case C-629/19, where the classification of a substance as waste or as a by-product was a point of issue, as well as the possible criteria for the substance to achieve end-of-waste status.[201] The occurrence of this type of confusion around end-of-waste is indicative of a legal certainty issue for actors trying to apply circularity in practice.

These concerns demonstrate the challenges around end-of-waste, leading to questions about possible alternatives that could be easier to implement. A few alternative instruments exist, such as standards, certificates and agreements, which could speed up the rate at which discarded materials from VFG can be reused.[202] Instruments that could be further developed, relevant to this, can be of both a top-down and bottom-up nature. The more bottom-up instruments are things like certification programmes, which can be negotiated between producers and consumers. On the more top-down side of things, there are instruments like 'eco-labels' or the 'Circular Economy' (CE) marking.

The EU Ecolabel is 'a label of environmental excellence that is awarded to products and services that meet high environmental standards throughout their life cycle: from the extraction of raw materials to production, distribution and disposal. The EU Ecolabel promotes the circular economy by encouraging producers to generate less waste and CO2 during the manufacturing process'.[203] While the Ecolabel provides a standard for broader environmental excellence (that includes furthering the circular economy), there are also specific 'CE' markings being developed for products that can result from better material cycling and closing of loops. For example, in 2019 the EU Regulation (2019/1009) came into force, laying down rules on the making available on the market of EU fertilising products.[204]

Part of this regulation laid down rules for making CE-marked fertiliser products available on the market and laid down common rules for the conversion of bio-waste into raw materials from which fertiliser products can be produced. This regulation sets the safety, quality and labelling requirements that fertiliser

[200] Caroline Attard, 'Overview of EU rules on waste & by-products, work underway on end-of-waste under the EU Circular Economy Action Plan' (Webinar on Regulatory questions around waste-derived algae & nutrient recycling, 22 March 2021).

[201] C. Backes, & M. Kajić (2022). cjeu (Case C-629/19: Sappi Austria Produktions-GmbH & Co. kg, Wasserverband 'Region Gratkorn-Gratwein'v Landeshauptmann von Steiermark: Suitable Recovery and Recycling Operations Surrounding Sludge in the EU). Journal for European Environmental & Planning Law, 19(3), 248-258.

[202] Johansson & Forsgren (2020), 1.

[203] Commission, 'The EU Ecolabel' (Commission Website, 2022); European Parliament and Council Regulation 66/2010 of 25 November 2009 on the EU Ecolabel [2009] OJ L27/1.

[204] European Parliament and Council Regulation 2019/1009 laying down rules on the making available on the market of EU fertilising products (Fertilizer Products Regulation) [2019] OJ L170/1, Annex III.

products must meet in order to be freely traded in the EU.[205] Manufacturers must demonstrate that their products meet these requirements, as well as restrictions on organic and microbial contaminants and physical impurities, before being able to claim the 'CE' marking.[206] In this way, it is ensured that trade takes place according to uniform rules that are valid for the entire EU market and in accordance with the general single market rules.[207] Trade in the same products without the CE mark within the borders of each EU Member State, and in accordance with nationally prescribed criteria and mutual recognition, is not restricted.

An example of a top-down instrument at the national level can be found in Sweden, which has its own certificate for digestate (waste from anaerobic digestion plants).[208] This certificate limits the possible sources for anaerobic digestion plants and ensures that technical requirements are continually updated. This has resulted in farmers and the food industry (who are usually reluctant to apply sludge, especially in the Netherlands), becoming more open to digestate. Such an example exists in the Netherlands, too, for aggregates (inert granular materials) from construction and demolition waste.

The Dutch Regulation on recycling granulate (Regeling vaststelling van de status einde-afval van recyclinggranulaat; e van Infrastructuur en Milieu, 2015) does establish requirements for the input materials: product control, product quality and quality assurance. However, these are always the same for all input materials, irrespective of whether they are classified as waste or as a product. This means that the use of a material is based on a risk assessment, not an overarching material classification, nor a concern about whether the material has been 'discarded' by a previous user. According to Johansson & Forsgren, in this Dutch law 'what matters is the concentration of contaminants and how the material shall be used', not its classification.[209] Although these types of examples are limited at the moment, they demonstrate that there is room to adjust our definitions of waste (and input materials overall) to close loops for certain waste streams.

On the whole, fertiliser products include compost, organic fertiliser, organo-mineral fertiliser, inorganic fertiliser, soil improver, growing medium, inhibitor, plant biostimulant and fertilising product blend. In the present study, compost is addressed as both an input material (component material) and as a product itself. Although this is not entirely aligned with the EU Fertiliser Products Regulation (No 2019/1009), which views compost simply as an input material, it is necessary because compost is sometimes the only product of VFG

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205 Ibid.

206 Ibid.

207 Croatian Agency for Environment and Nature (2018) 20.

208 Johansson & Forsgren (2020), 1.

209 Ibid.

reprocessing that the national legislation has deemed appropriate for application to agricultural land (as in the Netherlands).[210]

Application of product legislation

Without the presence of EU or national end-of-waste criteria specifically for VFG, we are left to approach the requirements for these products simply using the non-waste legislation and criteria relevant to them. This means that the recovered waste material streams have to conform to the same product standards as their virgin resource counterparts. Production of fertiliser in the EU is regulated mainly by Fertiliser Products Regulation (No 2019/1009), but the accreditation and market surveillance regulation (No 765/2008) and the REACH Regulation (No 1907/2006) are also relevant.

The Fertiliser Products Regulation (herein: FPR) harmonises the requirements for fertilisers produced from secondary raw materials and replaces the 2003 Fertiliser Regulation,[211] which only dealt with fertilisers from mined or chemically produced, inorganic materials.[212] The FPR is a reflection of the circular economy action plan, as discussed in the Commission's initial proposal for the regulation back in 2016.[213] The most important article in this regulation, from a waste perspective, is Article 19, which explains the novel idea that waste can cease to be waste if it is in compliance with product law. Article 19 states:[214]

> 'This Regulation lays down criteria in accordance with which material that constitutes waste, as defined in Directive 2008/ 98/EC, can cease to be waste, if it is contained in a compliant EU fertilising product. In such cases, the recovery operation under this Regulation shall be performed before the material ceases to be waste, and the material shall be considered to comply with the conditions laid down in Article 6 of that Directive and therefore to have ceased to be waste from the moment that the EU declaration of conformity was drawn up.'

Most of the legal issues surrounding fertilisers produced from secondary raw materials stem from the legitimate concern that recyclable organic sources of nutrients contain harmful substances (heavy metals, organic contaminants, pathogens).[215] Prior to the new regulation, limit values for different pollutants in fertiliser were regulated at the national level – with wide variation.[216] This tilted the competitive playing field between chemical fertilisers and fertilisers sourced

[210] Fertilizer Products Regulation [2019] Annex II.

[211] European Parliament and Council Regulation 2003/2003 of 13 October 2003 relating to fertilisers [2003] OJ L304/1.

[212] Fertilizer Products Regulation [2019] Recital 1.

[213] Fertilizer Products Regulation [2019] recital 1.1 and 1.2 and 1.11 (most importantly).

[214] Fertilizer Products Regulation [2019] Article 19.

[215] M. Sarvi, K. Ylivainio and E. Turtola, (2017) 'Report on compliance of recycled product with present EU fertilizer regulations', (Bonus Promise Deliverable 3, no. 11).

[216] Sarvi, Ylivainio & Turtola (2017) 4; Kelessidis and Stasinakis 2012, Mininni et al. 2017.

from secondary raw materials in favour of the chemical fertilisers.[217] The FPR aims to change this, as it now has a provision for end-of-waste through product law, and regulates both the end characteristics of fertiliser products (such as contaminants, nutrient levels) and the input materials for fertilizer products. As a result, the Commission hopes that the free movement of fertilisers sourced from secondary raw materials will improve, as will 'investment in this important sector of the circular economy'.[218]

Compliance with both the end-product and input material characteristics of all EU fertilising products is required by Article 4 of the FPR, which calls for the fertilisers to:

a. meet the requirements set out in Annex I for the relevant product function category;
b. meet the requirements set out in Annex II for the relevant component material category or categories; and
c. be labelled in accordance with the labelling requirements set out in Annex III.

Article 4 is also important because it requires EU fertilising products to not present a risk to human, animal or plant health, to safety, or to the environment.

As required by Article 4(1(a)), the end characteristics of fertiliser products are described in Annex I and are referred to as 'product function categories' (PFCs). The product function categories are Fertiliser, Organic fertiliser, Organo-mineral fertiliser, Inorganic fertiliser, Soil improver, Growing medium, Inhibitor, Plant biostimulant and Fertilising product blend. The specific requirements for the PFCs are varied, but they all focus on setting the required contents of various PFCs, limiting the presence of certain contaminants, setting the maximum residue limit values for certain substances and setting the maximum content of dry matter.

As required by Article 4(1(b)), the input materials are also divided into categories and given specific requirements in Annex II. The input material categories are referred to as Component Material Categories (CMCs). There are eleven categories all together, but only seven are relevant to the present research: Category 2 (Plants, plant parts or plant extracts); Category 3 (Compost), Category 4 (Fresh crop digestate), Category 5 (Digestate other than fresh crop digestate), Category 7 (Microorganisms), CMC 8 (Nutrient Polymers) and CMC 9 (Polymers other than nutrient polymers). Each of these categories is explained in more detail below.

Most of the categories (except plants, microorganisms and both polymer categories), are also covered by the REACH Regulation, concerning the registration, evaluation, authorisation and restriction of chemicals.[219] The REACH

217 Fertilizer Products Regulation [2019] recital 1.8.

218 Fertilizer Products Regulation [2019] recital 1.7.

219 Consolidated Version of the Regulation of the European Parliament and of the Council (EC) No 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals [2006]

requirements for CMCs vary slightly by category, but essentially require that the all substances incorporated into the EU fertilising product, have been registered pursuant to the REACH Regulation,[220] and that a chemical safety report has been carried out covering the use those substances in a fertilising product.[221] Their requirements include reporting on things like temperature, stability, flammability, solubility etc, for each of the materials in question.

According to the plants category (CMC 2), 'an EU fertilising product may contain plants, plant parts or plant extracts having undergone no other processing than cutting, grinding, milling, sieving, sifting, centrifugation, pressing, drying, frost treatment, freeze-drying or extraction with water or supercritical CO2 extraction.'[222] Additionally, the plants category includes both mushrooms and algae, but not blue-green algae (cyanobacteria).

The compost category (CMC 3) clearly defines what input materials obtained through aerobic composting can be included in an EU fertilising product. Relevant to the topic at hand, this can include bio-waste (within the meaning of the 2008 Waste Framework Directive), if the bio-waste fraction is separately collected at the source.[223] Further requirements include limitations on composting additives,[224] instructions on where and in what conditions the composting can take place (including temperature-time profiles),[225] the dry matter contents of compost[226] and the required stability criteria.[227]

The fresh crop digestate category (CMC 4) is similarly detailed in its definition of the permitted input materials for digestate obtained by anaerobic digestion. It allows only plants or plant parts grown for the production of biogas and digestion additives (the total concentration of which cannot exceed 5% of the total input material weight).[228] The Annex further specifies conditions in which anaerobic digestion can take place and the required stability criteria.[229] EU fertilisers can contain digestate other than fresh crop digestate (CMC 5), obtained through anaerobic digestion. One of the possible input materials is bio-waste (within the meaning of the 2008 Waste Framework Directive) if the bio-waste fraction is separately collected at the source – the same as for the

OJ L 396/1 (REACH Regulation).

220 With a dossier containing the information called for by Annexes VI, VII and VIII of the REACH Regulation.

221 Fertilizer Products Regulation (2019) Annex II, CMC 1 (2); CMC 3 (1(d)); CMC 4 (1(b)); CMC 5 (1(d)); CMC 6 (2).

222 Fertilizer Products Regulation (2019) Annex II, CMC 2 (1).

223 Fertilizer Products Regulation (2019) Annex II, CMC 3 (1).

224 Fertilizer Products Regulation (2019) Annex II, CMC 3 (1(d)).

225 Fertilizer Products Regulation (2019) Annex II, CMC 3 (2, 3).

226 Fertilizer Products Regulation (2019) Annex II, CMC 3 (4).

227 Fertilizer Products Regulation (2019) Annex II, CMC 3 (5).

228 Fertilizer Products Regulation (2019) Annex II, CMC 4 (1).

229 Fertilizer Products Regulation (2019) Annex II, CMC 4 (2, 3, 4).

compost category (CMC 3).[230] The same as for the other categories, the Annex defines the specific conditions of plants in which the anaerobic digestion can take place (including storage), the dry matter content requirements and the stability criteria.[231]

The requirements for the Microorganisms category of the FPR (CMC 7) are more brief. Simply stating that four species of microorganisms,[232] including 'dead or empty-cell microorganisms and non-harmful residual elements of the media on which they were produced can be included in EU fertiliser products', if they have undergone no other processing than drying or freeze-drying.[233] It is important to note that this CMC does not refer to input materials in the method itself. Meaning that the four species listed in the FPR can be included as CMCs specifically, but different microorganisms (such as actinomycetes, protozoa, rotifers and many others) can also be used in the composting or digestion processes.

The nutrient polymers category (CMC 8) is complex. A polymer is any class of 'natural or synthetic substances composed of very large molecules, called macromolecules'.[234] An EU fertilising product may contain polymers exclusively made up of monomer substances complying with the criteria set out in points 1[235] and 2[236] of CMC 1, where the purpose of the polymerisation is to control the release of nutrients from one or more of the monomer substances.[237] The remaining requirements for solubility, final degradation products and content of formaldehyde are also laid out.[238]

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230 Fertilizer Products Regulation (2019) Annex II, CMC 5 (1).

231 Fertilizer Products Regulation (2019) Annex II, CMC 5 (3, 4, 5, 6).

232 Azotobacter spp., Mycorrhizal fungi, Rhizobium spp., Azospirillum spp.

233 Fertilizer Products Regulation (2019) Annex II, CMC 4 (2, 3, 4).

234 'Polymer' (2020) Encyclopaedia Britannica.

235 CMC 1(1): An EU fertilising product may contain substances and mixtures, except: waste within the meaning of Directive 2008/98/EC, substances or mixtures which have ceased to be waste in one or more Member States by virtue of the national measures transposing Article 6 of Directive 2008/98/EC, substances formed from precursors which have ceased to be waste in one or more Member States by virtue of the national measures transposing Article 6 of Directive 2008/98/EC, or mixtures containing such substances, by-products within the meaning of Directive 2008/98/EC, animal by-products or derived products within the meaning of Regulation (EC) No 1069/2009, polymers, compost, or digestate.

236 CMC 1(2): All substances incorporated into the EU fertilising product, on their own or in a mixture, shall have been registered pursuant to Regulation (EC) No 1907/2006 (2), with a dossier containing: the information provided for by Annexes VI, VII and VIII to Regulation (EC) No 1907/2006 and a chemical safety report pursuant to Article 14 of Regulation (EC) No 1907/2006 covering the use as a fertilising product, unless explicitly covered by one of the registration obligation exemptions provided for by Annex IV to Regulation (EC) No 1907/2006 or by points 6, 7, 8, or 9 of Annex V to that Regulation.

237 Fertilizer Products Regulation (2019) Annex II, CMC 8 (1).

238 Fertilizer Products Regulation (2019) Annex II, CMC 8 (2, 3, 4).

In chemical fertilisers, polymers are traditionally used as technical additives (for example, to prevent the formation of lumps) or to facilitate the controlled release of fertiliser.[239] In the case of the later, granules of fertiliser are coated with a thin layer of polymer (micro-plastic) which facilitates the release of the fertiliser in a timely and targeted manner to various crops, with less losses to air and water.[240] In this way, the polymers ensure a high Nutrient Efficiency Unit (NEU) for the fertiliser product.[241] Although beneficial to the more efficient use of nutrients, the polymers contained in fertiliser increase the global problem of micro-plastics – which have been found to be harmful to both the environment and human health.[242] Currently, there are no alternatives to the polymers used in controlled release fertilisers and in technical additives. As part of the CE Action Plan, the EU Commission had put forward a proposal to restrict some intentionally added micro-plastics in products by 2021, including polymers used in fertilisers. The action around this topic points to the difficulty of striking a balance between different environmental issues. On the one hand, it is good for conservation of virgin resources if nutrients in fertilisers are released into crops in a timely manner; on the other hand, the micro-plastics with which this release is facilitated have negative effects on the environment and human health.

As part of this balancing act, a compromise was reached to find a workable solution. The European Chemical Agency (herein: ECHA), in a 2019 restriction report, promised a restriction on micro-plastics for most chemical sectors (as called for the Commission's proposal), but left fertilisers under the FRP exempt from this restriction – so long as they meet the requirements of the regulation for biodegradability.[243] As such, polymers other than nutrient polymers (CMC 9) are allowed in EU fertiliser products and can be found in the FRP, together with the requirement that the purpose of the polymer be one of the following:

a. to control the water penetration into nutrient particles and thus the release of nutrients (in which case the polymer is commonly referred to as a 'coating agent');
b. to increase the water retention capacity or wettability of the EU fertilising product;
c. to bind material in an EU fertilising product belonging to PFC 4.[244]

239 L. Della Pietra, 'The EU's push for biodegradable polymers in mineral fertilizers' (2019) Fertilizer Focus, 13.

240 Della Pietra (2019) 13.

241 Ibid.

242 Ibid.; J.C. Prata, et. Al., 'Environmental exposure to microplastics: An overview on possible human health effects' (2020) Science of the Total Environment 702: 134455, 1-6.

243 Della Pietra (2019) 13: 'intentionally added micro-plastics shall not be placed on the market as a substance on its own or in a mixture as micro-plastic in a concentration equal to or greater than 0.01% w/w'.

244 Fertilizer Products Regulation (2019) Annex II, CMC 9 (1).

Other requirements for non-nutrient polymers include biodegradability criteria[245] and precaution around the overall adverse effects of the polymer on animal and plant health, or the environment.[246] The biodegradability criteria are very important because they aim to ensure that the use of polymers does not lead to accumulation of plastics in the environment, by ensuring that the polymer is capable of decomposing entirely (into carbon dioxide, biomass and water) in natural soil conditions and aquatic environments across the Union.[247] The FRP's biodegradability criteria can be met only if the polymer can pass three tests: a plant growth acute toxicity test, an earthworm acute toxicity test or a nitrification inhibition test with soil microorganisms.[248] If fertilisers fail to meet these requirements for polymers they are subject to the same ECHA restrictions on micro-plastics as other chemical sectors.

Interestingly, the obligatory PFCs, CMCs and labelling requirements established by the FPR only apply to certified EU fertilising products. These are products with the 'CE' marking (explained earlier in the chapter), an administrative marking that indicates conformity with health, safety and environmental protection standards for products sold within the European Economic Area, as laid out by the market surveillance regulation.[249] However, the option for manufacturers of fertilisers not bearing the 'CE' marking to place their fertilisers on the market remains possible.[250] This is interesting because it is contrary to most other product harmonisation measures under Union law.[251] The possibility for non-harmonised fertilisers to be made available on the internal market (so long as they are in accordance with national law and general free movement rules of the TFEU) was first established by the 2003 Fertilisers Regulation and is maintained by the FPR.[252] As explained in the FPR, this option remains because of the very local nature of fertiliser product markets.[253]

In addition to the 'CE' marking, other components of the market surveillance regulation also apply to EU fertilising products,[254] specifically, Articles 16 to 29, which lay out a community market surveillance framework and controls for the products entering the community market.[255] These articles require Member States to carry out market surveillance, including establishing market

245 Fertilizer Products Regulation (2019) Annex II, CMC 9 (2).

246 Fertilizer Products Regulation (2019) Annex II, CMC 9 (3).

247 Fertilizer Products Regulation (2019) Art. 42(6).

248 Fertilizer Products Regulation (2019) Annex II, CMC 9 (3).

249 Fertilizer Products Regulation (2019) Art. 42(6); Regulation of the European Parliament and of the Council (EC) No 765/2008 setting out the requirements for accreditation and market surveillance relating to the marketing of products [2008] OJ L218/30 (Market Surveillances Regulation) Chapter IV.

250 European Council, 'EU adopts new rules on fertilisers' (EC Press Release, 21 May 2019).

251 Fertilizer Products Regulation (2019) Recital 5.

252 Ibid.

253 Ibid.

254 Fertilizer Products Regulation (2019) Art 37.

255 Market Surveillance Regulation (2008) Art 16-29.

surveillance authorities (with the necessary powers, resources and knowledge); implementing efficient cooperation and exchange of information between national market surveillance and those of other Member States; as well as sharing of resources and effective cooperation.[256] This is all set up to ensure that products benefiting from the free movement of goods within the community, such as fertilisers with the 'CE' marking, fulfil requirements like providing a high level of protection of public interests (health, safety, environmental protection, consumer protection, etc).[257]

In addition to various fertiliser products, the other products of VFG reprocessing are platform chemicals that can be used to make alternative materials like bio-based plastics. These are an example of alternative feedstocks, which can be developed to avoid using fossil resources.[258] In the EU, these feedstocks currently 'represent a small but growing share of the market'.[259] The main consideration with bio-based plastics is to ensure that they result in genuine environmental benefits compared to the non-renewable alternatives.[260] The European Commission has started work on understanding the life cycle impacts of alternative feedstocks in the production of plastics, including biomass and will look into the opportunities to support the development of alternative feedstocks in plastic production.[261] So far, the EU is mainly supporting these projects thorough funding for research and development (herein: R&D). For example, by 2018 Horizon 2020 had already provided over €250 million to finance R&D in areas of direct relevance to the EU strategy for plastics in the circular economy, of which bio-based plastics are certainly a part.[262]

Despite there being no specific legislation on this at the moment, only policy documents, there are still some relevant tools which could be used to drive bio-based production forward. EPR schemes, such as those on traditional plastic packaging could be relevant.[263] Little has been written about how this could relate to producers of vegetable, fruit and garden plants, although these are certainly often also packaged in plastic.

From the perspective of the EU on plastics, Member States' decisions 'on taxation and public procurement will also play a vital role in supporting transition and steering investments' relevant to bio-based plastics.[264] As such, the Commission emphasised the use of economic instruments to encourage waste prevention and recycling at national level. Finally, the EU will support these

[256] Ibid.

[257] Market Surveillance Regulation (2008) Recital 1.

[258] European Commission, 'A European Strategy for Plastics in a Circular Economy' COM/2018/028 final, 15.

[259] European Commission (2018), 15.

[260] Ibid.

[261] Ibid.

[262] Ibid.

[263] European Commission (2018), 16.

[264] Ibid.

products through structural and investment funds (in particular the cohesion policy funds) and future strategic research and innovation agendas.[265]

5.3.1 Dutch Requirements for Products Made from VFG

In the Dutch legislative landscape, the most relevant legislation and policy to this topic are the LAP3 and for fertilisers specifically also the Fertilisers Act (In Dutch: Meststoffenwet) and the implementing legislation for the Fertiliser Act (In Dutch: Uitvoeringsregeling Meststoffenwet, herein: UBMW).[266] At the national level, most attention around the reprocessing of VFG is geared towards reprocessing VFG for agricultural application (mainly as compost to be used as fertiliser).[267]

Composting is the second-most-preferred recycling option for VFG out of the three recognised in the LAP: the C1 category.[268] The precise definition of compost in Dutch law has been updated in 2019 with the addition of a requirement that compost must come from an aerobic process and may not be pumpable. The full definition in the LAP3 now reads:[269]

> '[Compost is a] product from an aerobic process consisting of one or more organic waste streams, that may or may not contain soil constituents mixed and broken down with the help of microorganisms, and converted into a homogeneous and stable end-product through the slow breakdown of humus compounds, which does not include animal fertilisers and cannot be pumped.'

The addition of these two criteria to the definition is meant to ensure that only stable products (with a high organic matter content, processed at high temperatures) are considered compost and that products from anaerobic processes are excluded.[270]

Waste, including VFG waste, can be used as a fertiliser under Dutch law if it is listed under Annex Aa of the UBMW.[271] The substances in the Annex are divided into four categories: I and II are substances that can be traded as

[265] European Commission (2018), 16.

[266] Uitvoeringsbesluit Meststoffenwet, UBMW (2005).

[267] LeAF Report (2020) 18, i-ii.

[268] LAP3, hoofdstuk A1, pg. 32.

[269] LAP3, Deel 7, p. 294.

[270] LeAF Report (2020) 18. There is disagreement as to whether this goal is actually achieved, considering the observation that: 'The explanatory memorandum to the UBMW states...that the addition 'aerobic' has been made to ensure that only products from processes with relatively high temperatures can be used. However, the authors give no indication as to which temperatures they consider to be relatively high. Based on the current definition, it cannot be stated that compost must have been warm. The fact that a process is aerobic is not sufficient to ensure that the temperature rises: open compost heaps and worm bins are also aerobic when properly executed, and high temperatures are not reached in them.'

[271] Uitvoeringsbesluit Meststoffenwet, UBMW (2005), Annex Aa.

manure, III are substances that can be used in the production of manure, and IV are substances that can be fermented together to create digestate. Digestate is legally considered to be manure, but is actually created through the co-fermentation of any of the substances listed under category IV of Annex Aa, in combination with at least 50% animal manure. If it meets these requirements, the digestate can then be traded as manure.

The list of substances in Annex Aa of the UBMW is expanded twice a year by the Ministry of Economic Affairs and by the 'Committee of Experts on the Fertilisers Act' (in Dutch: Commissie van Deskundigen Meststoffenwet). Anyone can submit a request to have a substance added to the list.

There are three main reasons why so much regulation around compost, fertiliser and other soil amendments exists at both the EU and national levels: to prevent unacceptable risk for the human health, risk for the environment and eco-system (including animals and plant life) and to facilitate trade. Regarding the first two reasons, as discussed in the general section of this chapter, critical levels of certain organic compounds, heavy metals chemical elements can gather in soil if land application of inappropriate soil amendments is permitted.

To prevent this, legislation sets maximum standards for critical levels of these elements in soil and in solutions put on the soil; crop quality standards for any products grown on soil; and drinking water quality standards (to ensure that drinking water has not been contaminated by solutions applied to adjacent farmland). Prior to harmonisation of the EU Fertilisers Regulation in 2019, the 2003 version of the Regulation left quite some room for non-harmonisation between the EU Member States, creating barriers to trade. The new version of the regulation aims to reduce these barriers by harmonising quality and protection standards for all EU fertilisers, but some additional trade requirements remain at the national level of the Netherlands.

Both the Meststoffenwet and the UBMW mainly focus on the end characteristics and quality control. The end characteristics include minimum quantities of nutrients (magnesium, calcium oxide, sulphur trioxide, sodium oxide), maximum values for organic micro-pollutants, content of copper and zinc, etc. Particular attention is also paid to nitrates, since this act is, in part, also the Dutch implementation of the EU's Nitrates Directive (91/676/EEC). One of the objectives of the Nitrates Directive is to reduce eutrophication of surface waters, which is important because eutrophication targets for phosphorus and nitrogen are continually exceeded in monitored surface water sites (especially those that are predominantly influenced by farmland).[272] The UBWM is part of the Dutch contribution to the achievement of these targets.

One of the main reasons why there are so many requirements on the input materials and end characteristics of fertilisers is that they are a substance that is applied to the soil. Soil is a carefully protected resource in the EU since it is the foundation for terrestrial life and the basis for a great deal of economic

[272] PBL Netherlands Environmental Assesment Agency, 'Evaluation of the Manure and Fertilisers Act 2016: Synthesis Report' (PBL Report, 2017).

production.[273] However, due to a 2006 Soil Protection Directive being rejected by many Member States, there is not a lot of harmonisation in this area at the EU level – apart from the EU's Thematic Strategy for Soil Protection (which is a policy document).[274] For this reason it is important that national legislation addresses soil protection issues. In addition to the quality control provided by the Meststoffenwet, the Netherlands also has the Soil Protection Act (In Dutch: Wet bodembescherming, herein: Wbb), which contains general rules to prevent soil contamination. The Wm is also relevant because it establishes that permits must be obtained before certain activities relevant to the soil may be performed. Permits must state the extent to which farmers/companies will take measures to protect the environment and the land, and there even may be a responsibility to return the soil to its original state.[275]

Regarding the third reason why there is so much regulation around this matter (removing barriers to trade), Chapter II of the Meststoffenwet sets out the Dutch 'Fertiliser Trading Rules'. According to its Article 4, in the interest of protecting the intended purpose of fertiliser, the soil, the marketing of fertilisers can be prohibited if these fertilisers do not comply with the following requirements:

a. the quality, nature, contents of certain substances and further composition, weight and packaging of fertilisers;
b. the name, directions for use and other indications for fertilisers;
c. the manner in which the declarations of fertilisers are made.

These requirements can be determined differently depending on the intended use of the fertiliser in question, and this is overseen by the Ministry of Economic Affairs.

Other products which can be made from VFG are bio-based plastics. While we know that market momentum is building around bio-based plastics (particularly to be used as a sustainable packaging alternative),[276] no Dutch legislation or policy relevant specifically to this was found over the course of this research.

5.3.2 Croatian Requirements for Products Made from VFG

In the Croatian legislative landscape, the most relevant legislation and policy for products made from VFG is again the ZGO and the 'Law on

[273] UK Environment Agency, 'The state of soils in England and Wales' (2014).

[274] Y. Chen, 'Withdrawal of European soil framework directive: reasons and recommendations.' Journal of Sustainable Development 13, no. 1 (2019), 2.

[275] Dutch Ministry of Infrastructure and Water Management, 'Legislation and instruments' (Rijkwaterstaat Website, 2022).

[276] A. Di Bartolo, G. Infurna & N.T. Dintcheva, 'A Review of Bioplastics and Their Adoption in the Circular Economy. Polymers' (2021) 13(8), 1229; S. Ramesh Kumar, P. Shaiju, & K.E. O'Connor, 'Bio-based and biodegradable polymers-State-of-the-art, challenges and emerging trends' (2020) Current Opinion in Green and Sustainable Chemistry, 21, 75-81.

Agriculture' (HR: Zakon o Poljoprivredi). Neither of these legislations nor the national PGO outline any specific definitions of the three relevant products that can be made from VFG (compost, fertilisers and bioplastics). The ZGO fully transposes the WFD, so it can be understood that the EU definitions of these products are fully adopted in Croatia as well. In addition to the definitions, the remainder of EU requirements around fertilisers and soil improvers are transposed into national law via the 'Law on Fertilisers and Soil Improvers' (NN 163/2003) and are a direct transposition with no additional requirements on permits, minimum standards for input materials or end characteristics.

Requirements for Compost and Digestate End-of-waste

Criteria for by-products and end-of-waste in the Croatian national system are outlined in the 'Ordinance on by-products and the abolition of waste status'. In a 2017 HAOP report on the topic of bio-waste, a total of 127,631 tonnes of material were declared a by-product (all of which was biological material), and 14,961 tonnes of bio-waste had its waste status abolished (i.e. achieved end-of-waste status). This is quite a large portion of the total 17,874 tonnes of all waste that achieved end-of-waste status. Of the nearly 15,000 tonnes of bio-waste that achieved end-of-waste status, half was waste from gardens and parks and half was food waste from kitchen and cantinas.

Before delving into the end-of-waste discussion for Croatia, it is interesting to note that the HAOP report discusses both by-products and end-of-waste status under the heading of 'end-of-waste status', and that the Croatian national legislation has grouped the two together under one implementing ordinance. This could be coincidental, as the topics of by-products and end-of-waste do share some overlap in that re-thinking the way we use and reuse both these products does play a role in lowering the total amount of discarded (landfilled) waste. However, it could also be yet another example of the struggle national governments face in untangling by-product and end-of-waste issues. This struggle is well illustrated in a 2019 case brought before the CJEU by an Austrian national court, Case C-629/19.[277]

As neither the EU nor the national frameworks require monitoring and reporting on the way in which end-of-waste products are used by their holders (requiring only data on the companies to which the products are sold), it is not clear how exactly these products are used and whether or not they re-enter the VFG life cycle via a feedback loop. The same is true for by-products, although for by-products it is easier to estimate what the materials were used for based on the information of the company to which they were sold. For example, HAOP estimates that roughly 70% of the by-products collected in 2017 were used in the anaerobic digestion process and as feed for pigs, because the by-products were sold mainly to biogas plants and pig farms.[278]

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277 Backes & Kajić (2022) 248-258.

278 Croatian Agency for Environment and Nature (2018) 41.

What we do know about end-of-waste products, on the other hand, is that the roughly 15,000 tonnes of bio-waste, was reprocessed into 9,852 tonnes of products (3,716 tonnes of anaerobic digestate, 2,596 tonnes of compost and 3,540 tonnes of wood chips and chipboard).[279] The HAOP report also concludes that, due to an absence of data, it is not possible to know for what these end-of-waste products were reused (or even if they were finally reused). However, this section of their report ends with a hope that the entry into force of the EU Regulation laying down rules on the application of fertiliser products with the 'CE' marking would strengthen the market for compost and digestate in Croatia, making the final stages of these feedback loops easier to track.

Bio-based plastics are not central to product legislation and policy, in neither Croatia nor the Netherlands, and this is likely because the total bio-based share of the chemical industry in the EU-27 is growing rather slowly (it rose from 11% in 2008 to 15% in 2018).[280] Or it could be the other way around, that the slow increase in the growth of the industry is caused by the lack of clear guidance in product legislation. These numbers are not restricted to only bio-based plastics but the overall percentage in any case is low, meaning that not a lot of biomass is used in the chemical industry.[281] Furthermore, bioplastics currently only represent about one percent of the more than 368 million tonnes of plastic produced annually. These low numbers of industry share hint that this has not been a massive focal point in our economies; however, this could change as desire for plastic-alternatives increases among consumers.[282]

5.4 Analysis

The first goal of the present research was to map all legislative and policy gaps within VFG materials' life cycle. The framework against which these gaps were evaluated is the EU's own circular economy objectives relevant to the recovery of organic matter from waste and the closure of loops therein. These objectives are to keep materials in the economy for as long as possible (resource efficiency),[283] and to keep their value as high as possible (waste

[279] The reason for this difference in tonnage is a reduction in moisture between the original waste material and the end-of-waste product. Both composting and anaerobic digestion significantly reduce the moisture content of material, thereby significantly reducing the weight of the final product.; Croatian Agency for Environment and Nature (2018) 37.

[280] Olaf Porc, Nicolas Hark, Michael Carus & Dirk Carrez, 'European Bioeconomy in Figures 2008–2018' (Bio-Based Industries Consortium Website, September 2021) 22.

[281] The raw material composition for the chemical industry is about 50% organic (fossil and bio-based) and 50 % inorganic (minerals, metals). If only the organic share is taken into account, because only this can be substituted by biomass; Porc, Hark, Carus & Carrez (2021) 22.

[282] Porc, Hark, Carus & Carrez (2021) 22.

[283] Waste Framework Directive [2018] Article 11.

hierarchy),[284] as part of the overarching goal of protecting a key product value chain: food, water and nutrients.[285] The present research found that the biggest gaps in this key product value chain, and the area where we are haemorrhaging the most circularity potential, is in the final stages of the cycle: reprocessing of VFG into alternative products.

The gaps in the life cycle become quickly apparent when a 'traffic light system' is applied to map and comparatively review the existence of various legislative and policy tools at the EU and national level (in the Netherlands and Croatia). This is done below in Table 4. The first column on the left is labelled to correspond to the four most relevant stages of VFG materials' life cycle (production of foodstuff, collection of waste, treatment and, finally, production of new products from recovered materials). The second column presents a list of all law and policy tools relevant to maximise the circularity of the VFG material life cycle.

The third column shows which of these tools can be found in law and policy at the EU level. It should be noted that this is only a 'first check' of whether the tool is present and not yet an assessment of whether the tool *should* be implemented because it substantially contributes to the desired circular economy objectives.

Table 5: 'Traffic light' table for law and policy tools for VFG materials

	Law and Policy Tools	EU	NL	CRO
Production (VFG Foodstuff)	Targets/requirements on use of CRMs			
	CAP, greater competence sharing			
	CAP, precision farming (ex: nutrient stewardship)			
	Taxes on (raw) materials and products			
	Soft law agreements			
Collection	Landfill targets			
	Landfill tax			
	Mandatory separate collection			
	Information			
	Kerbside collection			
	Dropoff points			
	Waste collection charges			
	Industry subsidies			
	Penalties for individuals			
	Reporting targets			

284 Waste Framework Directive [2018] Article 4.

285 Commission, 'A new Circular Economy Action Plan For a cleaner and more competitive Europe' (Communication, March 2020a) COM/2020/98 final, 12.

Treatment	Targets for recycling and preparation for re-use			
	Licensing of waste-to-energy facilities only for non-recyclable waste			
	Minimum treatment standards per waste stream			
	Exchange of information			
	Re-processing targets			
	Permitting and inspections			
	Additional requirements for ABPs			
	Quality criteria for compost and digestate			
	Monitoring and reporting			
	Industry subsidies 'recycling credit'			
	Penalties			
Products	End-of-waste criteria			
	Specific (separate) targets for re-use			
	Quality Control for Fertilizer Products			
	Quality Control for Bio-Based Plastic Products			
	CE Marking			
	Other labelling			
	Monitoring and reporting			
	Creation of markets for recycled raw materials			
	Green public procurement			
	Industry subsidies			

'Traffic light system' comparative review on the existence of various legislative and policy tools relevant to maximising the circularity of VFG materials' life cycle between the EU, the Netherlands and Croatia. A green cell in the table indicates that the tool is present in law and policy. A red cell indicates that the tool is not present, and a yellow cell indicates that the tool is present but with some limitations (i.e. it is not implemented in practice, it is only implemented by some municipalities, it only exists for some waste streams, etc). The same traffic light system is applied to the Dutch and Croatian legislative and policy frameworks in columns four and five.

Immediately upon first glance at the table, we can see that there are very few cases in which (at the same time/in the same row) the EU has a green light (green cell) and the Member States have a red light (red cell).[286] This

[286] The only examples of this are for policy tools like 'exchange of information', which is encouraged at the EU level to facilitate the sharing of technical know-how, but is not actively carried out at the Member State level with a lot of intention.

immediately confirms that the legislative frameworks of both Member States are largely in compliance with the EU framework.[287]

However, we can see a red light for both the EU and Member States in many areas. Although they appear throughout, they are most striking in the Treatment and Products stages of the life cycle. These red cells tell us, first of all, that there are some gaps at the EU level when it comes to treatment and creation of products.

The first problem relevant to this is that, due to delays, there are not yet technical minimum standards for treatment activities (including for recycling of waste that requires a permit). Article 27 of the WFD promises that the Commission shall adopt such delegated acts supplementing the WFD, but it has not done so yet. In addition to this, there is no mention of enforcement requirements for reprocessing installations performing treatment activities. This partially makes sense because the legislation aims to limit uncontrolled waste management mainly as it relates to potential dumping and littering. However, there is room here for stronger requirements on inspection and reporting for treatment facilities, especially with regard to their respect for the waste hierarchy. Even if this was only a reporting requirement, it would help provide more insight into the reprocessing situation in Member States, which is currently lacking. The question of who would oversee this reporting at the EU level relates back to the competence argument, which is expanded upon in Chapter 3 of the present research.[288]

Reprocessing and the creation of products are intrinsically linked, so another issue relevant here relates to product legislation. Reprocessing of VFG can result in three types of products: fertilisers, platform chemicals (bioplastics) and bio-energy (with bio-energy having been excluded from the scope of this study). As discussed in the present chapter, there is an extensive and comprehensive legal framework for fertilisers as products of reprocessed VFG, but the same type of framework does not exist for compostable, biodegradable and bio-based plastics at the EU level. This impacts the growth of the bio-based plastics market because there is a lack of standardisation in closing the loop for digestates and composts.

This is not a new finding, as its importance was already highlighted in the European Sustainable Phosphorus Platform's proposal for the Commission's 'Integrated Nutrient Management Action Plan'.[289] However, the present research does highlight how a lack of guidance in this area at the EU level affects advancement at the Member State level – where neither the Netherlands nor Croatia regulates recovered inputs to the bioplastics market. Due to the single

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[287] Past studies on similar topics have found that despite accurate transcription, the practical application of legal requirements (particularly in Croatia) are in their infancy; Croatian Agency for Environment and Nature (2018) 47.

[288] See Chapter 3 on the Legal Basis for the EU Action Relevant to the VFG and Sludge Material Streams.

[289] The INMAP is required by the Circular Economy Action Plan for this key value chain (p. 12); European Sustainable Phosphorus Platform, 'Proposed Considerations for the EU's 'Integrated Nutrient Management Action Plan'', 2.

market relevance of this matter, the EU is competent to intervene. Especially when public interests around the safety of introduced bioplastics and environmental interests around traditional plastics are taken into consideration.

Further relevant to product legislation are issues around end-of-waste status for VFG materials. Different Member States put varying levels of emphasis on end-of-waste, partly because of the varying accessibility of virgin materials and partly because of the differences in perception around acceptable risk level when it comes to reintroducing end-of-waste materials as products. Doctrinal research has found arguments that a shift away from end-of-waste to alternatives that focus more on the unexplored space between waste and products could level out this playing field. That space contains various instruments, such as standards, certificates and agreements, which could bypass end-of-waste status, at least in some cases.[290] This could speed up the rate at which discarded materials from VFG can be reused. Instruments that could be further developed, relevant to this, can be of both a top-down and bottom-up nature. The more bottom-up instruments are things like certification programmes, which can be negotiated between producers and consumers. On the more top-down side of things, there are instruments like 'eco-labels' or the 'Circular Economy' (CE) marking.

Another issue is that there are no targets for reuse (the way there are, for example, for collection). Environmental targets at the EU level create urgency around the uptake of EU environmental standards and give EU institutions the grounds to directly follow-up with Member States on problems in their progress in achieving targets.[291] Some could argue that reuse targets are one and the same as the recycling and *preparation* for reuse targets in WFD Article 11. However, 'preparation for reuse' (as stated in the WFD) is not reuse, and it does not explicitly require reuse that maintains resource efficiency and is in compliance with the waste hierarchy. Separate reuse targets in the WFD (not jumbled in with recycling targets) would more directly impact the CE objectives and would also give more weight to the existing collection targets. When experiencing the cycle holistically, one component drives the other: Member States are more incentivised to reach the collection targets and re-process their waste maximally in line with the waste hierarchy if they are also pushing to achieve reuse targets. There are several ways in which reuse targets could be formulated: weighted quantities of materials recovered for reuse; quantities of products manufactured from reprocessed VFG waste; fraction of the relevant market held by reused products (for example, share of bioplastics in the plastics market, or share of recovered fertiliser products in the wider fertiliser market) and so on. The Commission in collaboration with technical experts should select the most appropriate target formulation to achieve the greater CE objectives.

In addition to needing to be better addressed at the EU level, the red cells in the reprocessing and products segments of Table 4 tell us that the legislative landscape for reprocessing and reuse is fragmented at the Member State level.

[290] Johansson & Forsgren (2020) 1.

[291] Landfill Directive [1999] OJ L182/1; Commission (2019c).

Overall, for both Member States, some of the tools that are missing are those relevant to reporting around products and incentives for industry. Both the Netherlands and Croatia lack reporting requirements for treatment facilities and products made from end-of-waste materials, as well as some kind of database where all this information would be gathered and synthesised. The absence of this system (and the resulting insights) makes it difficult to track progress on closing feedback loops for materials like VFG. We have no insight into which quantities of VFG waste achieve end-of-waste status, what quantities are made into fertiliser products, what quantities are made into bioplastics or energy or what quantities in the end (still) end up landfilled. Traceability exists as a general principle in waste management,[292] and some version of it needs to be extended to include reuse of materials once they have achieved end-of-waste.

Part of the reason for the lack of independent industry action in this area is the uncertainty around creating novel markets for these products and potentially being a frontrunner in the use of some of the more experimental treatment methods. 'Daring' private actors to participate can be done either pressing on from one side to make current waste disposal methods (landfilling, incinerating) more financially unappealing. Alternatively, it can be done by pressing from the other side to make the alternatives more appealing. Relatively little of the latter is being done at the Member State level. Options for what could be done include subsidies for industry or green public procurement, both of which Table 4 has shown to be underused in the case of VFG. If Member States choose to use some of these tools, they have to make sure to incentivise actors across the entire value chain, to ensure holistic progress and avoid stakeholders working in silos.

For the Netherlands specifically, there were no major legal gaps or compliance issues with the EU level. However, one barrier that was identified was that compost is currently the only product of the VFG waste stream that can be applied to the soil as fertiliser. If consumer health and environmental protection concerns for other products were better balanced, more treatment methods could be applied and more recovery from VFG could occur.

In Croatia, there were no transposition issues, but there are gaps when it comes to the implementation of the waste legislation. This starts early in the life cycle of VFG products, even in the collection phase, which is why Croatia is also lagging behind the EU circular economy goals in the later parts of the life cycle. Efforts to improve compliance with reducing the landfilling of biodegradable municipal waste (through landfill taxes or better collection) could contribute to improvements in the reprocessing of bio-waste and creation of VFG products.

Kick-starting this is a priority, because Croatia could really be an ideal testing ground for some of these more small-scale treatment methods. Since the amounts of waste produced by Croatia are small (compared to more populous Member States, such as the Netherlands and Croatia) it could really focus the efforts of its treatment facilities to further develop some of these technologies

[292] Law on Waste Management (ZGO) NN 84/2021, Article 7.

and prove their efficacy. This way, Croatia could completely bypass the Dutch incineration model, 'leapfrogging' straight up the waste hierarchy to methods like recovery and reprocessing, which are higher up the EU waste hierarchy. Leapfrogging is a well-known concept, finding that countries that develop 'later' can skip some of the development stages and go straight to the most novel and advanced practices. An illustration of this concept are the many African nations that completely bypassed landline telephone, leapfrogging straight into the mobile phone age. Croatia could do the same when it comes to the management of VFG.

Another area in which Table 4 shows gaps is the start of the cycle, production of the original VFG foodstuff (i.e. agricultural production of vegetables, fruit and other plants) and the necessary conservation of virgin resources therein. This is the area in which the lowest number of legislative tools have been implemented, and of the four tools that have been identified, only one is present at both the EU and national levels: enhanced subsidiarity as a result of the new CAP. The revised CAP improved subsidiarity, extending to agriculture and goals for nutrient management. At the EU level, focus in the new CAP shifted to decision-support instruments, rather than control mechanisms: greater subsidiarity (to avoid one-size-fits-all solutions), the Farm Sustainability Tool for Nutrients (to facilitate better data collection and informed farming practices) and nutrient stewardship (precisions nutrition practices to conserve nutrients). However, more could be done at the national level in both Member States to facilitate better nutrient conservation in the agricultural sector.

Although raw materials are of great importance for Europe's economy, as well as the global economy as a whole (explained above in Section 1.1.1) there are no binding legal frameworks on critical raw materials at the EU level, nor in the national law of the Netherlands and Croatia. At the EU level, we have the Raw Materials Initiative and the list of critical raw materials. At the Dutch national level, we have the 2017 National Raw Materials Agreement, and in Croatia we have the 2018 Mineral Materials Management Strategy – neither of which are binding and neither of which set targets to minimise the market shares of virgin resource materials relevant to this topic.

The part of the table with the least red cells (relative to the number of tools identified), is collection. This is also the area with the largest number of tools already available and implemented in practice, indicating that collection is the part of the cycle at which the most legislative and policy attention has been directed. Despite many positive strides in collection, including local efforts to minimise waste creation, improve convenience of VFG waste collection for households and improve reporting, there are still gaps in the legislation and policy that could be barriers to the achievement of the circular economy objectives.

At the EU level, apart from the very specific collection targets, the language around collection in EU legislation is light. For example, Article 10 of the WFD states that Member States 'should' (not 'must') separately collect waste separately to improve recovery operations. There is also a very wide derogation possibility in cases where 'separate collection would entail disproportionate economic costs'. This makes sense considering the competence-balancing act, the context-specific nature of most collection systems (the specifics of which are familiar mostly only to local governments) and technical issues regarding the most sustainable way (or even the most circular way) to collect waste. The last of these is an issue for all waste streams, not just VFG, and is most easily demonstrated by the example of the Netherlands. For years the Netherlands has placed an emphasis on separately collecting as many waste streams as possible, but several municipalities are now re-integrating the plastic waste stream with the mixed municipal waste stream – even in parts of cities where VFG is not yet separately collected.[293] This means the plastic waste stream in contaminated with the bio-waste again, making both streams more difficult to clean and re-process. Although there are technical justifications for this change, this type of back-and-forth over how waste should be collected highlights an underlying lack of certainty over the 'best' way to collect and therefore also the 'best' way to treat collected waste.

The Netherlands is meeting existing EU collection targets due to a series of measures that it had made use of, primarily the landfill tax (which was so effective that there is no longer any need for it). In addition to this, most Dutch municipalities are trying to make use of the more common policy measures (access to information, door-to-door collection and conveniently located waste drop-off points) to encourage separate waste collection, where necessary. However, only one of the reviewed municipalities, Zwolle, has introduced a more novel monetary incentive scheme, such as pay-as-you-throw – which has been working well to achieved the desired circularity goals for VFG.[294] Several other Dutch municipalities that were not reviewed for the present research also use pay-as-you-throw schemes. At the municipal level, relatively little attention is paid to industry subsidies, and no attention at all is paid to penalties.

It seems that the main difference between both the provinces with the highest and lowest waste separation rates and between the neighbourhoods of a municipality that separate and do not separate VFG waste is the urbanisation of the area. This is not to say necessarily that urban municipalities are doing a worse job in setting up separate collection initiatives, but instead that they face a greater challenge due to the larger number of high-rise buildings and densely populated areas.

Croatia specifically, as a much newer EU Member State, is struggling to meet EU targets in this area.[295] The biggest problem is that Croatia is still not

[293] E. Dijkgraaf and R. Gradus, 'Post-collection separation of plastic waste: better for the environment and lower collection costs?' (2020) Environmental and Resource Economics, 77, 127-142; B. Andrews, 'Amsterdammers told to 'stop separating plastic' by City' (DutchReview Website, 8 January 2021).

[294] Interview with the municipality in Zwolle (Netherlands, 9th May 2022).

[295] The goal of separate collection of bio-waste from municipal waste for 2017 defined by PGO has not been achieved. Further, the goal of reducing the disposal of biodegradable municipal waste for 2016 defined

financially disincentivising unfavourable waste disposal methods, such as landfilling. Despite having an article in the ZGO calling for a landfill tax, no implementing legislation to achieve this has been developed.

In addition to this, the Croatian LSGUs are struggling to make use of the various instruments at their disposal to encourage separate waste collection. A great emphasis is placed on educating the citizen population about waste separation at the source, but often there is little online information on how to go about this waste separation in the specific systems of the LSGU and few other facilitating conditions (or other instruments) put in place. With the exception of the Čakovec LSGU, which clearly views waste separation, collection and treatment as a top priority, the LSGUs are struggling. The positive example of Čakovec demonstrated that perhaps the model for how Croatia could manage its waste does not need to come from another EU Member State, such as the Netherlands. Instead, it could come from within Croatia itself.

by the ZGO has not been achieved. Finally, in 2017 only 22% of LSGUs separately collected bio-waste; Croatian Agency for Environment and Nature (2018) 47.

CHAPTER 6

Legislative Framework for the Sewage Sludge Waste Stream

The present chapter will explain the legislative state of the art as it relates to sludge materials, once they are 'discarded' and become waste. As explained in Chapter 2, this research is structured around the life cycle of the organic matter contained within the sludge and VFG waste streams. Before looking at the life cycle from a legislative perspective, Chapter 2 explains the entire life cycle (of both VFG and sludge materials) from a general and biotechnological perspective. Chapter 3 provides a deep dive into the division of competences in this area between the EU and Member States. This is followed by the beginning of the legislative analysis of the two waste streams in Chapter 4, which looks at the first stage of the 'agricultural production' life cycle, which is the same for both VFG and sludge. After use by the consumer, the stories of these two waste streams diverge,[1] as do the chapters of this research. Collection, treatment (recycling and recovery) and creation of new products from VFG waste is addressed in Chapter 5, while the same for sludge waste is addressed here in Chapter 6.

Before delving into legal details of sludge collection, treatment and reprocessing into new products, it is essential to highlight and understand that (from a legal perspective) sludge is waste. A lot of effort is being taken to de-couple the word 'waste' from the idea that waste is a non-valuable material that can be freely discarded without much regard. So much so that some practitioners working in this field avoid the word 'waste' entirely, using terms like 'material streams', 'residues' or 'biosludges' instead. Considering that highlighting the value of organic materials contained in VFG and sludge waste streams is one of the core aims of this research, it was tempting to do the same. However, under EU law, sludge is defined as the material left over following the treatment of domestic and urban wastewaters, sewage plant wastewaters and wastewaters of a similar composition to those.[2] As such, it cannot be avoided that from a legal perspective sewage sludge currently is waste.

This means that when we track the life cycle of sludge materials, from the point where they are discarded by the consumer, the legal analysis always begins with waste law. Only after the requirements imposed on sludge materials by waste law are met can the story continue onto treatment methods and installations, as well as (finally) product law in the creation of new products from recovered material streams. This is supported by recent case law from the CJEU, which found that wastewater and thereby also the sludge contained within it, is not excluded from the scope of the WFD.[3] The WFD 'classifies wastewater as 'waste', but provides that in certain circumstances waste may fall outside the scope of the directive, if it is covered by other EU legislation.'[4]

1 With VFG being discarded into kitchen VFG and sewage sludge being flushed down toilets.

2 Sewage Sludge Directive [1986] Article 2.

3 Case C-629/19, Sappi Austria Produktions-GmbH & Co. kg and Wasserverband 'Region Gratkorn-Gratwein' v Landeshauptmann von Steiermark [2019] ecli:EU:C:2020:824.

4 Backes & Kajić (2022) 248-258; Case C-629/19, Sappi Austria Produktions-GmbH & Co. kg and Wasserverband 'Region Gratkorn-Gratwein' v Landeshauptmann von Steiermark [2019] ecli:EU:C:2020:824, para. 35.

Although it would be possible under that classification for sewage sludge to fall under other legislation, it does not. This is because the criteria of the WFD's Article 2(2) are not met, calling for 'the other legislation to have precise provisions organising the management of waste, ensuring a level of protection that is at least equivalent to that in the WFD.'[5]

6.1 Collection

Similarly to VFG collection, EU legislation around sludge collection aims to facilitate sludge collection in alignment with the circular economy objectives, while still ensuring safety for public health and the environment. Before even considering encouraging various preferable treatment methods, it was a key EU objective to minimise disposal of all waste (including sludge) in landfills. The 1999 Landfill Directive obliged Member States to reduce the amounts of biodegradable waste (including sewage sludge) sent to landfills 'to 35% of 1995 levels by 2016'.[6] As a result, at an EU-wide level reuse and incineration are the dominant sludge disposal methods, although some Member States (including Croatia) continue to use landfills as disposal outlets despite the environmental drawbacks of this practice.[7] Only 10.6% of total EU sludge processing continues to be landfilling.[8]

As explained in Chapter 2, sewage sludge is a component of urban wastewater and a by-product of urban wastewater treatment. This means that proper collection of urban wastewater, governed largely by the EU's Urban Waste Water Treatment Directive (91/271/EEC, herein: UWWTD), is central to encouraging both recycling of sludge and protection of public health and the environment in the process. The UWWTD seeks to 'protect the environment from adverse effects regarding urban wastewater discharges and discharges from several industrial sectors'.[9] The perambulatory clauses are also clear that the UWWTD seeks to encourage recycling of sludge derived from wastewater treatment, while phasing out the disposal of sludge to surface waters.[10]

The Directive looks at three forms of wastewater:[11]

- urban wastewater (domestic wastewater or mixture of domestic wastewater and/or runoff rainwater);
- domestic wastewater (wastewater from residential settlements and services which originates predominantly from human metabolism and household activities);

5 Waste Framework Directive [2018] Article 2(2); Backes & Kajić (2022) 248-258.

6 Landfill Directive [1999] Art. 5(2).

7 European Commission (2019b); Đurđević, Blecich and Jurić (2019) 4.

8 Đurđević, Blecich and Jurić (2019) 4.

9 Urban Waste-water Treatment Directive [1991] Article 1.

10 Urban Waste-water Treatment Directive [1991] Perambulatory clauses.

11 Urban Waste-water Treatment Directive [1991] Perambulatory clauses, para 1-3.

- industrial wastewater (wastewater discharged from premises used for carrying out any trade or industry other than domestic wastewater and runoff rainwater).

For these wastewaters, the directive requires Member States to determine competent authorities that will be in charge of monitoring the discharges from urban wastewater treatment plants (particularly the quantities and composition of sludge discharged) and submit situational reports to the Commission every two years explaining the situation around disposal of these discharges and urban wastewater more broadly.[12] However, the phrasing is light in these articles, with Article 17(3) stating that this kind of reporting will only be required 'if necessary', without much clarification on what 'if necessary' means in practice. This phrasing leaves a lot of leeway for Member States reporting. In the cases where reporting is necessary, the Commission and a committee consisting of Member States representatives makes a progress report on the subject every two years, with the possibility for resulting reasoned opinions and envisaged measures to improve the situation (if necessary).[13]

The Urban Waste Water Treatment Directive is mainly known for increasing the quantities of sewage sludge requiring disposal.[14] Following its coming into force, the EU saw around a 50% increase in annual sewage sludge production between 1992 and 2005.[15] The Netherlands and the other EU-15 members had to be in full compliance with the directive by 2005, but Croatia (as the newest EU Member State) has a different transition period stretching to 2023.[16]

Unlike with wastewater treatment, the EU currently has no official regulatory framework for the general management and disposal of sewage sludge in the EU. The only directive relevant specifically to sewage sludge is the Sewage Sludge Directive (86/278/EEC), which does not address the collection of sewage sludge, only the use.

When it comes to the collection of wastewater and sludge, the Waste Framework Directive (herein: WFD) is only relevant insofar as it seeks to discourage contamination of water resources. Its Article 1 aims to protect inland surface waters, transitional waters, coastal water and groundwater in order to:

a. prevent further deterioration and protection of the status of aquatic ecosystems;
b. promote sustainable water use based on long-term protection of available water resources;

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12 Urban Waste-water Treatment Directive [1991] Art. 15, 16 and 18.

13 Urban Waste-water Treatment Directive [1991] Art. 18(3).

14 Urban Waste-water Treatment Directive [1991] Art. 3 and 4.

15 A. Bianchini, et al. 'Sewage sludge management in Europe: a critical analysis of data quality.' International Journal of Environment and Waste Management 18.3 (2016): 226-238, 227.

16 Commission Staff Working Document, Evaluation of the Council Directive 91/271/EEC of 21 May 1991, concerning urban waste-water treatment, p. 140.

c. enhance protection and improvement of the aquatic environment by means of progressive emissions reduction;
d. ensure the progressive reduction of pollution;
e. contribute to mitigating the effects of floods and droughts.

These environmental protection aims further the cause for recycling of sludge materials because enhancing protection of water bodies pushes Member States to treat wastewater as much as possible and prevent runoff due to extensive fertilisation by farmers and the release of untreated water into the environment. However, it does not explicitly call for high-level treatment options that align with the waste hierarchy (including recovery and reuse of recovered materials). The same can be said for the Directive Concerning Urban Waste Water Management (91/271/EEC), which requires Member States to monitor discharges from urban wastewater treatment plants and especially the amounts and composition of sludge.[17]

For sludge, there are no separate collection requirements, no recycling or preparation for reuse targets, no waste collection charges, industry subsidies or penalties at the EU level. This means that, essentially, reporting requirements, landfill targets and environmental protection aims are the only tools currently available and employed at the EU level for sludge management. Because there is mainly only one EU directive, the UWWTD, that explicitly relates to sludge collection, it is clear that the practical matters surrounding sludge collection are mainly addressed at the national and sub-national level.

Member States that have had advanced wastewater collection and treatment systems for an extended period can collect more sludge. In the Netherlands, 'wastewater collection and treatment system already served more than 94% of the population' in 1991 when the UWWTD was adopted and 'major cities, such as Amsterdam, Eindhoven, Rotterdam and The Hague already provided at least secondary treatment' of wastewater.[18] The major advantage this head start provided for the Netherlands is also evident in the fact that it 'is one of the few countries with no ruling of the CJEU related to the implementation of the UWWTD'.[19]

A broad duty of care is implemented through the Dutch Environmental Management Act (Dutch: Wet Milieubeheer, herein: Wm) and applies to wastewater, as the Dutch Council of State confirmed in 2008 that wastewater falls under the definition of waste in Dutch law.[20] The duty of care requires that anyone 'who performs or fails to perform actions with regard to waste and who knows or could reasonably have known that adverse consequences for the environment arise or could arise as a result, is obliged to take or refrain from taking all measures that can reasonably be required of him, in order to prevent

[17] Urban Waste-water Treatment Directive [1991] Art. 15(1); Dijkshoorn & de Best (2020) 11.

[18] Commission Staff Working Document (1991) 140.

[19] Commission Staff Working Document (1991) 141.

[20] Uitspraak 200704332/1 (Eng: Ruling Raad van State), ECLI:NL:RVS:2008:BD4479.

or limit those consequences as much as possible'.[21] This broad duty of care tries to ensure that the environment is always a consideration before action is taken.[22]

The Wm is also the Dutch transposition of the European WFD, particularly with respect to the definitions of 'waste', 'by-product', the waste hierarchy, mixing of waste, the end-of-waste criteria etc. The various stages of the sludge materials' life cycle where the Wm applies are further discussed below.

Another relevant act is the Water Act (Water Wet) and its underlying decree and regulation. Because there are no kerbside collection or drop-off points for sewage sludge waste, the entirety of the burden of collection is on the municipal service providers, not the citizens themselves. The responsibilities of water boards and municipalities relevant to wastewater (and sewage sludge therein), as called for by the Water Wet and the Wm, are explained well in a report from 2020:[23]

> 'The Water Act imposes a duty of care on both water authorities and local municipalities. Water Authorities are required to purify municipal wastewater, whereas municipalities are required to collect all forms of water (i.e. wastewater and rainfall).[24] To fulfil this duty of care, municipalities are required to draft a municipal sewage plan (Dutch: *gemeentelijk rioleringsplan*).[25] Although drafted on the municipal level, a number of parties have to be involved in its drafting such as the water authorities, sewage authorities and the province.[26] The plan contains an overview of the sewage facilities for: the collection of urban wastewater, collection and treatment of runoff rainwater, measures aimed at preventing or mitigating adverse effects of groundwater levels, overview of replacements and construction during the planning period, the way facilities are managed and the consequences for the environment by present and planned facilities.'

The Netherlands does not require mandatory separate collection of sludge, nor do there exist industry subsidies or penalties for collectors.

In Croatia, less than 55% of the population was connected either to collecting or urban wastewater treatment in 2013 when it became an EU Member State.[27] This lag in wastewater collection is part of the reason why today Croatia also lags behind other EU Member States in collection and utilisation of sludge.[28]

The current wastewater system is governed by the Water Act NN 66/19, 84/21 (HR: Zakon o vodama). It does not require mandatory separate collection of sludge, and there are no industry subsidies or penalties for collectors.

[21] Art. 10.1 Wet Milieubeheer (Eng: Law on Environmental Conservation).

[22] Dijkshoorn and de Best (2020) 14.

[23] Dijkshoorn and de Best (2020) 15.

[24] Art. 3.4-3.5 Water Wet (Eng: Water Act).

[25] Art. 4.22 Wet Milieubeheer (Eng: Law on Environmental Conservation).

[26] Art. 4.23 Wet Milieubeheer (Eng: Law on Environmental Conservation).

[27] Commission Staff Working Document (1991) 134.

[28] Eurostat (2022).

Croatia's new 'National development strategy until 2030' (HR: Nacionalna razvojna strategija Republike Hrvatske do 2030 godine) promises improvements in municipal wastewater treatment as part of the chapter on 'Protection of natural resources and the fight against climate change'. This demonstrates an awareness of the links between improved wastewater collection and the conservation of valuable resources. The strategy goes on to highlight that investments will be made in 'the modernisation and expansion of...devices for municipal wastewater treatment'.[29]

When it comes to sludge within wastewater specifically, an important role of ensuring that sludge is treated for recovery is to limit its landfilling. Considering that sludge landfilling is often the cheapest disposal option for wastewater treatment plants, it will only be reduced if it is limited by legislative means. The situation when it comes to landfilling of sludge in Croatia is confusing. First, Article 80(2) of the Water Act forbids the landfilling of untreated sludge that meets the definition of Article 80(1). That definition encompasses all sludge derived in the process of cleaning wastewater. However, the Waste Management Act 084/2021 (Zakon o gospodarenju otpadom NN 084/21) does not list sludge as one of the materials that cannot be landfilled, but it does suggest preferred treatment routes in Annex I.[30] The conclusive law seems to be the rulebook on the methods and conditions of waste disposal (categories and conditions of operation of waste disposal sites).[31] Wherein, Article 5(1) states that landfills cannot accept waste 'if its mass of biodegradable components exceeds 35% of the total weight'. Biologically stabilised sludge always contains more than 35% biodegradable matter, meaning that its landfilling is always prohibited.[32] There are no special regulations for the case of thermal or chemical treatment of sludge.

6.2 Treatment (Recycling, Recovery, Reprocessing)

As explained in the VFG chapter: recycling of materials from biomass waste streams, such as sewage sludge, offers a series of benefits through the conversion of 'waste' into a hygienic product, diversion from landfills and the provision of valuable materials, as well as possible revenue.[33] Recovery and recycling helps avoid the loss of natural resources (both material and energy) that went into food production, as well as helping avoid potential environmental harm (such as environmental pollution and greenhouse gas

29 Nacionalna razvojna strategija Republike Hrvatske do 2030. godine (Eng: National development strategy of the Republic of Croatia until 2030).

30 Law on Waste Management (ZGO) NN 84/2021, Article 25, Article 39 and Annex I (D2, D4).

31 Pravilnik o koIičinama i uvjetima odlaganja otpada, kateIorijama i uvjetima rada za odlagališta otpada NN 117/2007, Article 5 (1).

32 Banić, Ivan, 'Obrada i zbrinjavanje mulja s uređaja za pročišćavanje otpadnih voda' (Thesis, Polytechnic College Pula, 2017).

33 Lohri et. Al. (2017) 81.

emissions) through the diversion of sludge from landfills. The recycling of sludge in the present research looks at both requirements around input waste materials and around treatment installations – at both the EU and Member State levels.

The relevant legislation on recovery and recycling installations at the EU level are the Waste Framework Directive (herein: WFD), Environmental Impact Assessment Directive (herein: EIA; 2011/92/EU) and the Directive on Industrial Emissions (herein: IED; 2010/75/EU) and the Shipment of Waste Regulation (No 1013/2006).

6.2.1 Permitting for Waste Management and Recovery Operations

Any industrial installation, including large WWTPs, must go through a permit process. According to Articles 3 and 15 of the WFD, if waste is to be used as raw material for fertiliser production, the installation performing this will most likely be classified as a 'waste manager' and is required to ensure appropriate waste treatment.[34] Such installations, labelled 'waste managers', have to follow rules much stricter than fertiliser companies that use phosphate rock, creating another barrier for those who wish to recycle and recover raw materials for fertiliser from waste.[35] Recovery operators, on the other hand, require registration (WFD, Art. 26), but may be exempted from the more tedious permit process because 'recovery of waste' is one of the exemptions listed in Article 24 (WFDs Art. 23 and 24).

To gain the status of 'fertiliser producer', extra permits and new installations are also needed for WWTPs – this is an additional practical and financial burden.[36] Furthermore, registering a new (sustainable) fertiliser type can take up to seven years, further blocking innovation in this area. As a result, WWTPs often choose to sell the recovered P as waste, instead of turning it into fertilisers.[37] However, this is currently changing in the Netherlands. In addition to sludge being incinerated, part is undergoing digestion, with P extracted from the liquid phase and sold as fertiliser.[38]

Definitions of 'waste management' and permits requirements for waste recovery operations may seem like relatively minor administrative considerations, but these are exactly the barriers that can hinder innovation. If there is an innovative solution for nutrient recovery, but the company does not have a licence to treat 'waste' (and the process for getting the licence is a major

34 S. Hukari, L. Hermann and A. Nättorp. 'From wastewater to fertilisers—Technical overview and critical review of European legislation governing phosphorus recycling.' Science of the Total Environment 542 (2016): 1130.

35 De Boer et. Al. (2018) 1790.

36 De Boer et al. (2018) 10-11.

37 Ibid.

38 A detailed diagram of this process can be found in Appendix 2.

administrative or financial burden) then the circular solution will not be brought to market. This is a barrier. Additionally, if it is unclear whether a specific process qualifies as a waste recovery operation, companies may refrain from engaging with it, to avoid the risk of having to go through a re-licensing process.

6.2.2 EIA, IED and BAT/BREF Requirements

Once an installation has complied with any relevant WFD requirements, the EIA, IED and BAT/BREF requirements become relevant.[39] Whether the EIA and IED apply to a certain treatment installation depends on that installations size and treatment capacity, as well as on national legislation implementing the directive and on the judgement of regional authorities. It should also be noted that these directives only apply to certain treatment methods and that they do not prescribe which treatment options an installation should choose for which waste stream.

Instead, this is done on the basis of the WFD and national law and policy documents, as described above. As elaborated in a 2016 study by Hukari et.al., 'in practice, both EIA and IED oblige operators to submit relevant information concerning their processes and plants to the authorities, which in turn may grant an operation permit with or without certain conditions'.[40] Recovery or recycling installations are not explicitly mentioned in the EIA directive but a permit is required for plants such as fertiliser factories and certain waste disposal installations.[41]

The treatment method requirements in the IED relevant to sludge are the same as those relevant to VFG, described in section 5.2 of Chapter 5 of the present research. These requirements are relevant to both biological treatment and physico-chemical treatment (as listed in Annex 1).[42] This means the directive could potentially apply to composting, vermicomposting, black soldier fly treatment and densification (if the treatment installations were large enough), although it does not explicitly mention them by name.[43] It is also highly unlikely that any BSF or vermicomposting treatment facilities would be large enough to fall under the IED. The biological treatment that the directive does mention by name once is anaerobic digestion. Anaerobic digestion is mentioned in Article 5(3) of Annex 1, in relation to capacities for recovery for non-hazardous waste: 'When the only waste treatment activity carried out is anaerobic digestion, the capacity threshold for this activity shall be 100 tonnes per day'.[44] This is an

39 Industrial Emissions Directive [2010] OJ L334/17.

40 Hukari, Hermann and Nättorp (2016) 1130.

41 Industrial Emissions Directive [2010] Article 12 in combination with Annex I. Hukari, Hermann and Nättorp (2016) 1130-1131.

42 Industrial Emissions Directive [2010] Annex 1.

43 Industrial Emissions Directive [2010] Annex 1, Art. 5.2.

44 Industrial Emissions Directive [2010] Annex 1, Article 5(3).

example of the size and capacity requirements needed for installations to come under the scope of the IED.

As touched upon in the VFG chapter, certain installations also need to take into consideration the BAT standards – the best available techniques or technologies, which are targets for industry practices, developed and improved over time along with our societal values and technological advancements.[45] In the EU, the best available techniques for a variety of industrial sectors are described in BAT reference documents (Best Available Techniques Reference Documents, or BREFs).[46] There is a specific document on waste incineration, the objective of which is to stimulate installations to take into account the recovery of phosphorus from incineration ashes, including inciting separate incineration of high-P streams to generate ash with P recovery potential.

Although this is a BREF standard, it does not yet regularly occur in practice across the EU because while many EU Member States do have sewage sludge incineration plants, relatively few are carrying out recovery of organic matter at a large scale.[47] The Netherlands is one of the EU Member States that does have incineration installations that carry out this kind of recovery. A recent report on the Netherlands from the EU's Phos4You project described:[48] 'Dutch water authorities possess two sludge incineration facilities in which about 700,000 tonnes of wet sludge is incinerated. The other approximately 700,000 tonnes of wet sludge are separated, dried and co-incinerated in waste-to-energy plants or composted and co-incinerated, either in the Netherlands or in surrounding countries. HVC and SNB have been the owners and operators of the two incineration plants in Dordrecht (province of Zuid-Holland) and Moerdijk (province of Brabant) since the early 1990s.'

In addition to the EIA and IED, the Shipment of Waste Regulation is also relevant for sludge treatment. This Regulation applies to WWTPs that would like to export their recovered products (sewage sludge or struvite), which are labelled as waste for recycling across borders. The Regulation states that a contract should be set up between the person responsible for the shipment of the waste and the receiver of the waste and that authorities from both the country of origin and the destination country need to authorise the shipment. This process is currently very time-consuming, while importing phosphate rock does not have to undergo any such shipping process, making it easier to import the virgin raw material than the P containing waste.[49]

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45 Industrial Emissions Directive [2010] Art 3(10); 'best available techniques' means the most effective and advanced stage in the development of activities and their methods of operation which indicates the practical suitability of particular techniques for providing the basis for emission limit values and other permit conditions designed to prevent and, where that is not practicable, to reduce emissions and the impact on the environment as a whole.

46 Industrial Emissions Directive [2010] Art 3(11).

47 M. Gerritsen, C. van Aert, J. Ruijter, and L. Sijstermans 'Sewage sludge ashes for P-recovery purposes in The Netherlands' (Phos4You Report, April 2021), 6.

48 Gerritsen, van Aert, Ruijter and Sijstermans (2021) p. 6.

49 De Boer et al. (2018) 10-11.

6.2.3 Dutch Requirements for Recycling of Sludge

The central legislative and policy documents for the management of wastewater sludge in the Netherlands are the Environmental Management Act (in Dutch: Wet milieubeheer, Wm), the General Provisions of Environmental Law Act (Dutch: Wet algemene bepalingen omgevingsrecht, herein: Wabo), the Environmental Management of Activities Decree (Dutch: Activiteitenbesluit) and the LAP3 (Dutch National Waste Plan), specifically Sector Plan 16.

Considering that both sewage sludge and VFG are considered 'biomass' under the law, the same permitting procedures described for VFG in Chapter 5 also apply here for sludge.[50] In short, the Wm sets the environmental protection requirements and puts limitations on environmental hindrances of installations (through minimum standards for treatment, for example), while the Wabo determines the competent authority for different treatment methods and installations (including permitting requirements and inspections). The permitting process for these installations depends on several factors at all institutional levels, which is why it is described in detail in Chapter 5 of VFG.

Following environmental protection and permitting requirements, the LAP3 further elaborates on the requirements for sludge treatment. It implements the EU waste hierarchy, outlines requirements for various specific treatment actions (such as mixing of waste streams, for example) and specifies exactly which treatment methods are possible or mandatory for sludge. Since the 1998 Boom Decree (discussed below in the section on sludge product), it has not been permitted to spread sewage sludge on agricultural land. In 1998, the concerns around sewage sludge use were mainly related to its content of copper and zinc; however, nowadays the concerns are also about micro-plastics and organic contaminants.[51] For this reason, the LAP3 requires thermal treatment of sewage sludge prior to application.[52]

Other treatment is only possible when it is proven that it is at least as good as thermal treatment when it comes to eliminating contaminants.[53] Recovery of substances from sludge (such as phosphate, bioplastics and so on) is permitted, with the caveat that what remains after recovery may not be deposited.[54]

Further environmental rules that apply to treatment installations are set out in the Environmental Management Activities Decree. This decree applied to 'establishments' (Dutch: 'inrichting'), and both this decree and the Wabo outline

50 See section 5.2.3 of Chapter 5 on VFG.

51 Gerritsen, van Aert, Ruijter and Sijstermans (2021) p. 6.

52 Sectorplan 16 Waterzuiveringsslib, 'Minimumstandaard voor vergunningverlening (a)' (Eng: Sectorplan 16 Sludge Water treatment, 'Minimum standard for licensing (a)'), p. 1.

53 Gerritsen, van Aert, Ruijter and Sijstermans (2021) p. 6.

54 Sectorplan 16 Waterzuiveringsslib, 'Minimumstandaard voor vergunningverlening (a)' (Eng: Sectorplan 16 Sludge Water treatment, 'Minimum standard for licensing (a)'), p. 1.

what companies and activities are considered 'establishments'.[55] A company that falls under the Activities Decree has to make a notification when it starts or changes its activities. A specific explanation for how competence is carried out through the Activities Decree is discussed at length in Chapter 5 of VFG, and is relevant here for Sludge as well.[56] For example, reporting the use of contaminated soil, the delivery of waste, the transport of waste or an unusual incident.

6.2.4 Croatian Requirements for Recycling of Sludge

Treatment of sludge in Croatia is mainly governed by the Waste Management Act 084/2021 (HR: Zakon o gospodarenju otpadom NN 084/21). This law obliges sludge treatment facilities to record the generation and flow of waste into an electronic register called e-ONTO and lists some of the recommended treatment routes in Appendix I.[57] This is important to facilitate appropriate reporting of collected quantities, so that appropriate treatment of collected quantities can be monitored. The waste management plan for the year 2017-2022 (HR: Plan gospodarenja otpadom Republike Hrvatske za razdoblje 2017-2022 godine) and the proposal for the new waste management plan for the year 2023-2028 are further relevant. The plans state the investment priorities in the waste sector for the next five years. One of the central aims defined in the plan is the 'establishment of a system for managing sludge waste from wastewater treatment plants'.[58] No concrete actions are mandated, but the inclusion of this aim in the plan demonstrates and awareness of the need for improvement in treatment of this waste stream and the valuable resources therein.

This awareness is necessary as construction of a WWTP where the final disposal of sludge has not been resolved is considered incomplete, as not all necessary environmental protection measures have been taken to ensure appropriate sludge management.[59] The degree of environmental protection required comes from the EU level, with Article 14 of the UWWTD calling for sludge derived from wastewater treatment to be reused whenever appropriate, with disposal routes minimising 'the adverse effects on the environment'.[60] The fact that Croatia has not yet achieved this is highlighted in paragraph 1.2.2.13 of the National Waste Management Plan, which finds that 'in the Republic of Croatia, there is no adequate system for managing waste sludge from wastewater treatment plants, which primarily refers to the necessary infrastructure for treatment'.[61]

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55 Ministry of Infrastructure and Water Management, 'Environmental regulation system'.

56 Domazet (2022).

57 Law on Waste Management (ZGO) NN 84/2021, Article 25, Article 39 and Annex I (D2, D4).

58 Plan gospodarenja otpadom Republike Hrvatske za razdoblje 2017. – 2022. godine (Eng: Waste Management Plan for the year 2017-2022), sub-goal 2.2.

59 Domazet (2022).

60 Urban Waste-water Treatment Directive [1991] Article 14.

61 Plan gospodarenja otpadom Republike Hrvatske za razdob–je 2017. – 2022. godine (Eng: Waste Management Plan for the year 2017-2022) NN 1/2022 , Para 1.2.2.13.

Croatia currently relies on other EU Member States for the disposal of its waste sludge, for example, the city of Maribor pays 200 euros per tonne of sludge to Austria for the thermal disposal of its sludge.[62] This practice is not appreciated by the EU, as it goes against Article 16 of the principle of proximity (that waste should generally be managed as close as possible to its place of production, because transporting waste has a significant environmental impact). This is further substantiated by Article 11 of Regulation 1013/2006 on the shipment of waste, which outlines grounds for objections to shipments of waste destined for disposal.[63] To replace this cross-border trade of sludge waste, Croatia is trying to develop its own sludge management system, with a preference for the development of raw material streams from waste within the country itself.

A study on the topic of sludge management in Croatia, for the Croatian scientific journal of ecology, governance and ecology (EGE journal) found that there is no 'one-size-fits-all' solution for sludge management. Instead, it recommends that the various stakeholders decide on the most appropriate sludge application (at a local or regional level) and develop the collection and treatment system to fit that chosen application.[64] In Croatia, it is rare that a supplier of wastewater services, together with local self-government units, has a selected optimal sludge disposal solution in mind. Selecting such a solution would require them to know where the sludge will be disposed of (or what products the material streams within it could be made into), what characteristics it should have, the price of its disposal and the risks that come with each potential solution.[65]

The EGE journal article on this topic identified four barriers to proper sludge management in Croatia (two of a legal nature and two of a governance nature). The first is that the law does not penalise those who dispose of sludge in an illegal way. Actors in this sector wish to avoid paying the additional costs of sludge processing, so they look for alternatives and are not sufficiently penalised when they dispose of sludge illegally. The second legal barrier is the shortcomings of the Ordinance on by-products and the abolition of waste status, which are discussed in the following section of this chapter on 'Products recycled from the sludge waste stream'.[66]

The third barrier, which is of a more economic and governance nature, is that a solution for the management and appropriate disposal of sludge was not included in the initial plans when building and investing in Croatia's WWTPs. Instead, it was stated in the plans that sludge was a problem that 'would be

62 Domazet (2022).

63 Regulation (EC) No 1013/2006 of the European Parliament and of the Council of 14 June 2006 on shipments of waste [2006] OJ L 190/1.

64 Domazet (2022).

65 Ibid.

66 Ibid.

solved later, in a different way'.[67] These plans were approved by the EU and received EU funding. The final barrier is the expectation on the part of local self-government units and water service providers that another institutional level holds the competence and legal responsibility to create a solution for sludge management. Dr. Dražen Vouk, an engineer from the Faculty of Civil Engineering of the University of Zagreb, explained in the EGE article that 'water service providers and local self-government units expect MINGOR and 'Hrvatske vode' to solve sludge disposal, whereas the law is clear that the obligation to dispose of sludge is solely the obligation of the body that creates it'.

When it comes to a suitable solution for sludge management, the EGE journal study suggests that the solution might be more organisational and economic (supported by appropriate legislation and regional policy plans). The study finds that, considering Croatia's growing sludge accumulation, regionalisation of sludge processing and disposal is the most favourable solution for all relevant actors. Regionalisation would mean that each region would have its own regional waste centre, part of which would perform anaerobic digestion of the sludge, with the main resulting product energy.

The regional centre would collect sludge itself (where necessary), but would also accept additional sludge from the surrounding WWTPs. This would allow the regional centre to be energy independent, but also to supply energy to the market (reducing the negative economic balance of the operation of the entire plant). Accepting non-stabilised sludge from the surrounding WWTPs would improve the production of energy, which is a benefit for the regional centre, as well as for the surrounding WWTPs (which do not have to stabilise their sludge and can therefore reduce their own energy consumption).

Accepting the sludge from the surrounding WWTPs in the regional centre increases the total amount of processed sludge that needs to be disposed of. The regional centre can charge the WWTPs a fee for accepting sludge, with which it can cover these disposal costs (and since the total amount of sludge will be larger, the regional centre will be able to achieve a lower unit price of disposal services on the market, which is a benefit for both it and the smaller WWTPs).

Although this solution is supported by experts, such as Dr. Vouk, it is not an entirely circular solution to sludge, since the focus is mainly on energy, meaning that there would still be disposal (and waste) of the valuable organic material streams held within sludge. Although regional collaboration at this level is important, it should include a possibility of recovery of organic matter from sludge with respect to the EU waste hierarchy and the circular economy objectives. In addition to better regional organisation and governance, the present study also finds that legislation can play a significant role in improving sludge management, specifically when it comes to end-of-waste and product law (as described in the section below) – both in the Netherlands and Croatia.

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[67] Ibid.

6.3 Products Recycled from Sludge Waste

Recovered sludge, the recycled materials obtained therein, could be used in several ways. They could be recycled into fertilisers or other soil supplements to be used in agriculture, used as components of other products (such as bioplastics) or used as energy. Although direct application of sludge is forbidden in both the Netherlands and Croatia, some of the products recovered from all three of these product routes can still be used.

All legislation and policy relevant to this stage of the sludge life cycle are considered in the context of Articles 114 (Internal Market) and 191 (Environment) of the TFEU.[68] With this legal basis, it is regulated that products are placed on the EU market in such a way as to ensure the free movement of goods, while also abiding by other EU objectives of safety, environmental protection, rational utilisation of natural resources, energy efficiency and protection against unfair commercial practices.[69]

When it comes to market placement of recycled materials, there is EU law relevant for two separate 'categories': recycled products (materials that comply with product-related legislation) and recycled materials with waste status (materials that comply with waste legislation).[70] End-of-waste criteria (Article 6, WFD) are relevant for both groups. For 'recycled products', relevant legislation is the REACH Regulation and the classification, labelling and packaging of substances and mixtures legislation and the Mutual Recognition Regulation. For 'recycled materials with waste status', the relevant legislation is the Shipment of Waste Regulation and the WFD. For products intended for use in agriculture, the Fertiliser Regulation and the Sewage Sludge Directive are also relevant.

6.3.1 Recycled Materials with Waste Status

For use in agriculture, the Sewage Sludge Directive (86/278/EEC) is relevant because it prohibits Member States from using sludge with a high concentration of heavy metals and requires the treatment of sludge before it is used for agricultural purposes in order to prevent soil deterioration.[71] The Sludge Directive applies to recycled materials with waste status. According to the Directive, Member States are required to ensure up-to-date records with regard to the quantity of sludge, its composition, the type of treatment carried out, names and addresses of recipients of the sludge and the place where

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68 Commission, 'Roadmap: Towards an EU Product Policy Framework contributing to the Circular Economy' (Ref. Ares(2018)2409307 – 07/05/2018b), 2.

69 Ibid.

70 This useful classification is reflected in several academic works on this topic, but this clear phrasing is borrowed from Hukari, Hermann and Nättorp (2016) 1130.

71 Sewage Sludge Directive [1986] Article 5 and 6; Dijkshoorn and de Best (2020) 9.

the sludge is used.[72] Sludge producers are required to provide users with information with regard to the composition of the sludge every six months. If results of analyses do not significantly vary over a full year, analyses can be reduced to once every twelve months.[73]

The Directive also requires that sludge should be used in such a way that account is taken of the nutrient requirements of plants and that the quality of the soil and of the surface and groundwater is not impaired.[74] This includes protection against the oversupply of nutrients and ensuring safe food production. In this way, the European Union aims to both encourage the application of sewage sludge in agriculture and prevent possible risks.[75]

The Sludge Directive was adopted more than 20 years ago, and the European Commission is currently evaluating whether it should be reviewed. For example, the Directive sets limit values for seven heavy metals; however, since its adoption, several Member States have enacted and implemented stricter limit values for heavy metals and set requirements for other contaminants. Furthermore, some countries set regulations for maintaining soil pH within set limits to avoid leaching of heavy metals into the soil.[76] For its assessment of the Sewage Sludge Directive, the European Commission has launched a study to gather existing information on the environmental, economic and social as well as health impacts of present practices of sewage sludge use on land. This study will also assess the risks and opportunities that can be foreseen in the coming years and hopefully provide some legal coherence in this space.

Legislation relevant to recycled materials with waste status, which can be obtained from both VFG and sludge recycling (such as compost, digestate, nutrient polymers), is discussed in the VFG chapter and does not need to be repeated here. However, there are agriculture-related recycled materials specific to the sludge stream: struvite, bio-char and ashes.

For all these product streams, the EU's end-of-waste criteria are relevant. As explained in the preceding VFG chapter,[77] criteria for end-of-waste were formulated in Article 6(1) of the 2008 revisions of the WFD and were not changed in the 2018 consolidation. As discussed in Chapter 5 for VFG, the product status can be achieved under the following four criteria:[78]

1. the substance or object is to be used for specific purposes;
2. a market or demand exists for such a substance or object;
3. the substance or object fulfils the technical requirements for the specific

[72] Sewage Sludge Directive [1986] Art 9.

[73] Sewage Sludge Directive [1986] Art 10.

[74] Sewage Sludge Directive [1986] Art 8.

[75] D. Fytili & A. Zabaniotou, 'Utilization of sewage sludge in EU application of old and new methods—A review' (2008) Renewable and sustainable energy reviews, 12(1), 116-140.

[76] S. van der Kooij et. Al, 'Phosphorus recovered from human excreta: A socio-ecological-technical approach to phosphorus recycling' (2020) Resources, Conservation and Recycling, 5.

[77] See section 5.3 of Chapter 5 on VFG.

[78] Waste Framework Directive [2018] Art. 6.

purposes and meets the existing legislation and standards applicable to products and
4. the use of the substance or object will not lead to overall adverse environmental or human health impacts.

The original intention was that these criteria would be expanded upon for each waste stream, but at the moment only three exist, for: iron scrap, copper scrap and glass cullet.[79] A number of public and private actors have signed a joint letter to the Commission, calling for emphasis to be placed on the development of 'EU end-of-waste status for the value chain food, water & nutrients'.[80]

Because there is no EU end-of-waste criteria for product streams coming from sludge (struvite, bio-char, ashes), it is left up to the Member States to develop their own criteria. Without end-of-waste criteria, we are left with only the non-waste legislation relevant to these same products when they are not sourced from waste.

All three of these products are mentioned in the consolidated 2003 Fertiliser Products Regulation (No 2019/1009, herein: FPR). The FPR places certain quality control requirements on fertiliser products prior to their entry into the single market. If fertilisers meet all the requirements in the FPR, they are given the 'CE' marking (indicating compliance with health, safety and environmental protection standards for products sold within the European Economic Area). This can improve a fertiliser's marketing position; however, getting the marking is no small administrative feat and can take up to five years.[81]

The FPR finds that a market demand for the use of struvite, bio-char and ash-based products has been identified and that the development of input requirements is necessary 'to ensure that the use of those fertilising products does not lead to overall adverse environmental or human health impacts'.[82] The FPR's Annex I lays out a list of EU fertiliser types, known as product function categories (herein: PFCs). For each of these PFCs, the Annex states the required characteristics of the products, such as form, minimum levels of nutrients, neutralising value and contaminant limit values, as well as the origin and production process. Products on the PFC list automatically receive European end-of-waste status.[83] Neither struvite, nor bio-char, nor ashes meet these PFC requirements.

79 Johansson & Forsgren (2020) 1.

80 This letter came about as the result of the European Commission assessing opportunities for development of EU End-of-Waste rules for a number of waste streams, as announced in the Circular Economy Action Plan (CEAP). The CEAP designates ($3.7) 'Food water and nutrients' as a key product value chain; Mattia Pellegrini, Silvija Aile, Enrique Garcia John, Peter Wessman. 'Joint letter: EU End-of-Waste status for the value chain Food, water & nutrients' (Phosphorus Platform Website, 3d May 2021).

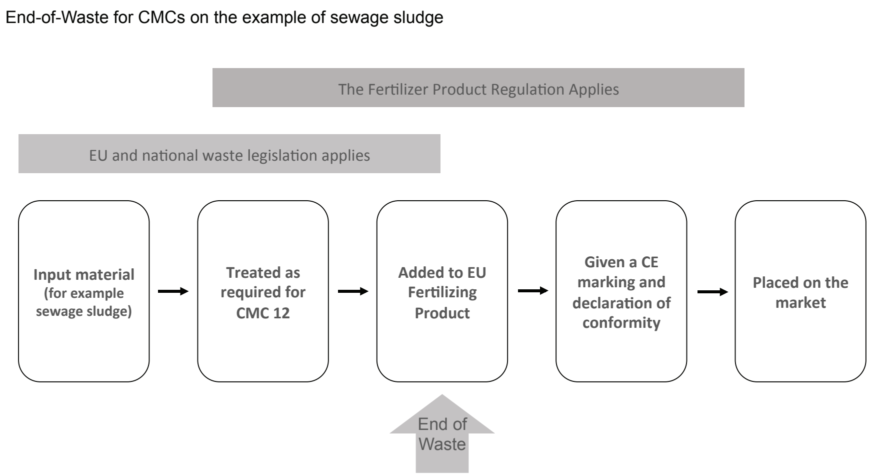
81 De Boer et al. (2018) 10-11.

82 Fertilizer Products Regulation [2019] Recital 19.

83 Fertilizer Products Regulation [2019] Annex I; Ean den Dungen & van Schöll (2022) 5.

Article 42(2) of the old FPR called for the Commission to assess struvite, bio-char and ash-based products, to check if the criteria in Article 42(1(b)) are met and if these materials can be added into Annex II, which lists 'Component Material Categories' (herein: CMCs).[84] These products do not automatically receive European end-of-waste status, meaning that national legislation continues to apply to all permitted components until they have been processed into an EU fertilising product with a 'CE' marking.[85] As illustrated in Figure 9 below, the waste status for these materials ends only when they become part of an EU fertilising product, prior to this waste legislation must also be complied with for transport and processing.

Figure 9: Path to End-of-Waste for CMCs, on the example of sewage sludge (CMC 12)



The EU's Joint Research Centre (herein: JRC), supported by the European Sustainable Phosphorus Platform (herein: ESPP), determined that the conditions were met and all three product streams were included in Annex II.[86] The JRC developed the 'STRUBIAS criteria', on which the 2019 revisions were based.

[84] Fertilizer Products Regulation [2019] Article 42(1(b)) requires that scientific evidence finds the relevant fertilising products to (i) not present a risk to human, animal or plant health, to safety or to the environment; and (ii) ensure agronomic efficiency; as required by Article 4(1(b)) of the Fertilizer Products Regulation the input materials for these products are divided into categories and given specific requirements in Annex II. The input material categories are referred to as Component Material Categories (CMCs).

[85] Van den Dungen & van Schöll (2022) 8-9.

[86] The Joint Research Center was commissioned to investigate under which safety and quality requirements struvite, biochar and ashes can be included in the CMC list; European Sustainable Phosphorus Platform, 'ESPP input to the three public consultations on STRUBIAS materials' (ESPP Website, 11 February 2021), 9; van den Dungen & van Schöll (2022) 9.

Under this criteria, struvite is listed as CMC 12 'Precipitated phosphate salts and derivatives', ashes are listed as CMC 13 'Thermal oxidation materials and derivatives' and bio-char is listed as CMC 14 'Pyrolysis and gasification materials'.

The consolidated FPR came into effect in 2019, with a three-year transition period. During the transition period EU Member States had time to develop standards to assess the conformity of various product streams with the new safety and quality requirements, as well as to appoint designated notification bodies (sometimes 'conformity assessment bodies' or CABs) to carry out the conformity assessments.[87] In order for struvite, ashes or bio-char to be used as a CMC, the national notification body has to carry out an independent conformity assessment.[88] There is no record of these notification bodies or applications in Croatia. In the Netherlands, the notification bodies are listed on the NVWA website. Dutch bodies for struvite and bio-char do exist, but at the moment there is no Dutch body that carries out the certification of EU fertilisation products for CMC 13, relevant to ashes.[89]

As of early 2022, very few notification bodies had applied for accreditation across EU Member States. The ESPP is concerned 'that the lack of CABs will prevent products covered by the FPR from accessing the single market, which will be detrimental to industries and farmers alike'.[90]

6.3.2 Recycled Products

Once end-of-waste status for products streams recovered from sludge is achieved through the FPR, these materials become 'recycled products' (materials that comply with product-related legislation, rather than waste legislation). As such, their market entry becomes dependant on compliance with the European Chemical Regulation (REACH, No 1907/2006), the classification, labelling and packaging of substances and mixtures legislation and the Mutual Recognition Regulation. All chemical substances that are traded in Europe must be registered and approved through the REACH legislative framework.[91]

Producers are required to complete the REACH registration for their product stream.[92] However, producers of the same product stream are also required to share safety information and prepare a joint safety file.[93] A producer who newly enters the market can buy access to an existing security file by submitting a

87 van den Dungen & van Schöll (2022) 8-9.

88 Fertilizer Product Regulation (2019), Article 24, 32 and Annex IV 'Conformity assessment procedures'.

89 Van den Dungen & van Schöll (2022) 8-9.

90 European Sustainable Phosphorus Platform, 'Urgent need for conformity assessment bodies for fertilising products' (ESPP Website, 20 May 2022).

91 De Boer et al. (2018) 10-11.

92 Consolidated Version of the Regulation of the European Parliament and of the Council (EC) No 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals [2006] OJ L 396/1 (REACH Regulation), Article 22.

93 REACH Regulation, Article 11.

registration through the existing consortium of manufacturers or the lead registrant.[94]

There are several exceptions to the REACH registration requirement. For experimental product streams, it is good to note that, at least at first, there is no need to register the substance if the quantities produced are less than one tonne of dry substance per producer. This is important so that registration is not an additional administrative burden in the pilot phase of production.[95] In addition to this, Article 2 (7.d) provides an exception to the registration requirement recovered substances, under two conditions:

1. the substance that results from the recovery process is the same as the substance that has been registered in accordance with Title II and
2. the information required by Articles 31 or 32 relating to the substance that has been registered in accordance with Title II is available to the establishment undertaking the recovery.

The first condition essentially finds that, as long as the substance's first operator can demonstrate sameness of the recovered substance (with the registered substance), the second and subsequent operators are exempt from the obligation to register the substance.[96] The second condition applies to substances classified as hazardous and requires the preparation and sharing of the mandatory safety data sheet.

For struvite, even though the European Chemical Agency has no harmonised classification, it does report that there are no notified hazards by manufacturers, importers or downstream users of struvite,[97] which is why struvite has obtained approval under REACH in 2015. Some uses of struvite are considered dangerous and are therefore restricted. Annex XVII of REACH on 'Restrictions on the Manufacture, Placing on the Market and Use of Certain Dangerous Substances, Mixtures and Articles' restricts struvite use in cellulose insulation mixtures.[98] Other uses of struvite are not restricted, and it can be traded on the EU single market, even without registration – according to the Commission's interpretation of REACH Article 2(7.d).[99]

For bio-char, recent cooperation between the lead registrant for charcoal and the bio-char industry actors has led to the possibility for bio-char to be registered via the existing charcoal consortium.[100] At the time of writing, there was no

94 REACH Regulation, Article 11, 19 and Annex VI.

95 Van den Dungen & van Schöll (2022) 8-9.

96 REACH Regulation, Article 2; European Sustainable Phosphorus Platform, 'ESPP information note on recovered struvite and regulation' (ESPP Website).

97 European Chemicals Agency, 'Struvite Substance Infocard' (ECHA Website).

98 REACH Regulation, Annex XVII.

99 European Sustainable Phosphorus Platform, 'ESPP information note on recovered struvite and regulation' (2023).

100 Biochar is a chemically-modified product derived from organic compounds; therefore, REACH registration as an UVCB substance is mandatory for every producer placing biochar on the market. There

evidence of ashes recovered from sludge being registered in REACH or joining an existing consortium. Interpretation of the REACH rules is complicated, which is why the Dutch government has initiated the REACH helpdesk. There is no Croatian equivalent of such a helpdesk.

The labelling, 'CE' marking and market surveillance requirements applicable to fertiliser products made from VFG waste (and discussed in Chapter 5), also apply to the struvite, bio-char and ash product streams made from sludge waste.[101] Additionally, the classification, labelling and packaging of substances and mixtures Regulation ((EC) No 1272/2008, herein: CLP Regulation) also applies. The CLP 'closely interacts with REACH regarding the safe use and handling of chemicals'.[102]

In addition to the above discussed legislation, the EU's proposed eco-design regulation COM(2022) 142 final, which is part of the 'Sustainable Products Initiative', contains important provisions on this topic from a product law perspective.[103] The central aim of the regulation is to reduce the negative life cycle environmental impacts of products and improve the functioning of the internal market. The regulation 'also contributes to the objectives of EU industrial policy to boost the supply of and demand for sustainable goods, deliver on sustainable production, and ensure a level playing field for products sold on the internal market'. Though the regulation does not apply to food and feed, it does apply to fertilizing product and could apply to bio-plastics (though it does not mention them explicitly). It is particularly positive that the regulation proposal focuses on conservation of critical raw materials, meaning that it will target the beginning stages of the material lifecycles relevant to this topic (and that valuable resources, like phosphorus and other organic matter, will be conserved to a greater extent). As such, the various eco-design approaches outlined in the regulation, including product passports and labels, will apply to and be an important driver for closing VFG and sludge loops in several stages of their material lifecycles.

Further to being important for the materials at hand, the Eco design Regulation proposal is also important for consumers, as it sets out to provide common standards of protection in many areas, including (and relevant to VFG and sludge) product safety and the environment.[104]

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are existing REACH dossiers for charcoal made from wood (EC# 240-383-3) and coconut shells (EC# 271-974-4). Biochar from other types of feedstock are not registered yet, but can be through the existing consortium and their dossier; H. Bier, 'BioChar goes REACH' (Biochar Industry Website, 11 August 2020).

[101] See 'Critiques of End-of-Waste' in section 5.3 of Chapter 5 on VFG.

[102] Hukari, Hermann and Nättorp (2016) 1131.

[103] Proposal for a Regulation of the European Parliament and of the Council 2009/125/EC of the 30th of March 20233 establishing a framework for setting ecodesign requirements for sustainable products and repealing Directive (Ecodesign Regulation) [2022] COM/2022/142 final, Context of the proposal, p 1.

[104] European Commission (2018b) 2.

6.3.3 Transport of Recycled Products vs. Recycled Materials with Waste Status

Lastly, with regard to these product streams, a note on transport across the European community. When a substance is classified as waste, the European regulation on the shipment of waste (herein: EWSR) applies for cross-border transport. Among other things, the EWSR contains criteria to ensure that waste shipment is in accordance with environmental protection standards. It does this through the 'green list' procedure and the 'orange list' procedure. For the green list, no authorisation from authorities is required; only an information obligation suffices (a completed and signed information form must be present during transport, as required by Annex VII). For the orange list, a notification procedure is applied (permission for transport must be requested from the transport authorities in the countries concerned).

When the substance has an end-of-waste status, there are different procedures because the substance no longer falls under the scope of waste legislation but under product legislation (as explained earlier). A European end-of-waste status is valid in all EU Member States, and the substance is therefore recognised as a product everywhere. At the moment, this EU-wide status exists for struvite, will soon exist for bio-char and does not yet exist for incineration ashes. When it comes to national end-of-waste status, the EWSR continues to apply when the substance is being transported if the recipient country still regards the substance as waste. If the recipient country recognises the substance as a product, the conditions of the EWSR no longer apply.[105]

Continuing this work on developing criteria for PFCs and CMCs, as well as expanding the relevant consortium dossiers under REACH, is critically important for improving the desired closed-loop system around waste recycling within the circular economy, but it is not only relevant for fertilisers. Micronutrients and heavy metals, which can also be recovered from sludge, have a vast potential for re-entry to the single market if end-characteristic or end-of-waste criteria are developed for them. Especially considering the EU's desire, expressed in the Communication on the New Industrial Strategy for Europe, to reinforce its industrial and strategic autonomy – specifically also for non-energy raw materials through recycling and use of secondary raw materials.[106] While it is beneficial that these feedback loops are regulated in the fertiliser sphere of the market, there are other uses for these product streams for which some legislative foresight is required.

For example, there is no equivalent of FPR for other product streams that are being recovered from sludge, such as platform chemicals. Although many of these recovery operations are still in the pilot stages, it is not too early to

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[105] van den Dungen & van Schöll (March 2022), 5; Rijkswaterstaat, 'Afvaltransport over de grens (EVOA)'.

[106] Communication from the Commission to the European Parliament, the European Council, the Council the European Economic and Social Committee and the Committee of the Regions, 'A New Industrial Strategy for Europe' COM/2020/102 final.

begin harmonising requirements for input materials and end characteristics. In August 2021, a study came out from the European Chemicals Agency (herein: ECHA) on the chemical recycling of polymeric materials from waste within a circular economy, which came to many of the same conclusions as those identified in the present research. The main argument is that the definition of recycling is still tricky in the EU; that chemical recycling technologies that aim to contribute to the circularity of platform chemicals differ in their ability to do so (and need to be evaluated on a case-by-case basis); and that traceability of substances is a key problem to be resolved.[107]

6.3.4 Role of National Authorities

It is also interesting that so much in this area is left to the judgement of national authorities. Especially considering the amount of variety present in the implementation of legislation relevant to sewage sludge recycling. To use the example of the Sewage Sludge Directive, which aims to encourage the use of sewage sludge in agriculture and to regulate its use while preventing harmful effects on soil, vegetation, animals and humans, we see that Member States' understanding and implementation of this Directive run in opposite directions. The same Directive has led to both Spain forbidding the incineration of sewage sludge and the Netherlands determining that all sewage sludge must be incinerated.[108] Spain is one of the six Member States that choose to allow application of *treated* sewage sludge in agriculture, putting in place strict limit values for heavy metals and other pollutants, largely similar to the limit values set out in Annex IB of the Sewage Sludge Directive (86/278/EEC).[109]

Although this type of broad interpretation is good for innovation around different ways to manage sewage sludge, it does lead to a degree of uncertainty in the internal market where crops grown on agricultural land where sewage sludge was used can be freely traded. This demonstrates a lack of legal certainty and a lack of a single rationale that underpins the legal system (a characteristic necessary for coherence).[110]

In the Netherlands, the Ministry of Economic Affairs and Climate Policy (*Dutch: Ministerie van Economische Zaken en Klimaat, herein: EZK*) is responsible for two segments of the sewage sludge cycle: the environmental and natural

[107] Z. Manžuch, et. Al., 'Chemical Recycling of Polymeric Materials from Waste in the Circular Economy' (ECHA Report, August 2021) vi-vii.

[108] Dijkshoorn and de Best (2020) 3.

[109] The other five member states are Greece, Luxembourg, Ireland, Italy, Portugal and Spain; P. Aubain, et. Al., 'Disposal and recycling routes for sewage sludge. Synthesis report for the European Commission DG Environment-B/2. P' (2002) 15, 21, 33.

[110] I.M. de Waal, 'Coherence in law: A way to stimulate the transition towards a circular economy? A critical analysis of the European Commission's aspiration to achieve full coherence between chemicals legislation and waste legislation–and product legislation.' Maastricht Journal of European and Comparative Law 28.6 (2021): 760-783.

resource segment, as well as the commercial and industrial product segment.[111] Meanwhile, the Ministry of Agriculture, Nature and Food Quality (Dutch: Ministerie van Landbouw, Natuur en Voedselkwaliteit, herein: LNV) is responsible for agricultural policy, food safety and natural conservation.

In Croatia, the Ministry of the Economy and Sustainable Development (*Croatian: Ministarstvo gospodarstva i održivog razvoja*, herein: MINGOR) is the competent ministry for oversight of sewage sludge and wastewater management as a whole, but when it comes to agricultural policy and food safety the Ministry of Agriculture has competence.

6.3.5 Dutch Requirements for Products Made from Sludge

Dutch fertiliser law and policy is based on the EU Sewage Sludge Directive, the LAP3, the Nitrates Directive and the Water Directive. These have been implemented in several national acts: the Boom Decree, the Meststoffenwet (Fertilisers Act) and the Wet bodembescherming (Soil Protection Act). The Sewage Sludge Directive has been transposed into national legislation mainly through the 'Decree on the quality and use of other organic fertilisers' (Dutch: Besluit kwaliteit en gebruikveragee organische meststoffen), abbreviated to 'Boom'.[112] The decree entered into force on 1 January 1993 and was updated in 1998.[113] In addition to transposing the Sewage Sludge Directive into national law, the Boom Decree sets more stringent limit values for heavy metals in sludge and in soil.

This decree brought an end to the spread of sewage sludge on agricultural land in the Netherlands.[114] However, the use of product streams recovered from sewage sludge is still possible, although strictly regulated. The remainder of this section discusses the regulatory framework the Netherlands has set up to facilitate the safe use of these recovered product streams. Of the various product streams that can be recovered from sewage sludge, the Dutch legislative framework has expanded on EU law surrounding: phosphates recovered from sludge (especially struvite) and ashes, but is solely focussed on their use as fertilisers in agriculture (not as bioplastics).

The LAP3 (Dutch National Waste Plan) is relevant not only in the treatment part of the life cycle but also for encouraging the closing of loops through useful application of products recovered from waste. For example, the LAP3 set a target that by 2021 at least 95% of all waste must have a useful application, with the

111 This is also why it has commissioned several reports on the state of affairs when it comes to regulations and standards for fertilisers, particularly those made from waste materials; P.A.I. Ehlert et. Al. 'Appraising fertilisers: origins of current regulations and standards for contaminants in fertilisers: background of quality standards in the Netherlands, Denmark, Germany, United Kingdom and Flanders' No. 336. Wettelijke Onderzoekstaken Natuur & Milieu, 2013.

112 Gendebien (2010) 20.

113 Ibid.

114 Ibid.

target for household waste being even higher at 99%. Although ambitious, these types of goals are important because all levels of government in the Netherlands (national, provincial and local) are 'required to take the LAP into account when carrying out or making decisions that revolve around waste, offering a uniform and consistent waste management'.[115] This is a necessary step towards coherence around circularity as a common national objective. The LAP is drafted by the Minister of Infrastructure and Water Management (Dutch: Minister van Infrastructuur en Rijkswaterstaat) every six years. Derogation from the LAP is permissible where necessary if this is justified in relation to the entire life cycle of the waste stream.

Product streams recovered from sewage sludge have two possible entry points into the Dutch market: through classification as a fertiliser or through achievement of end-of-waste status.

a. Classification as a Fertiliser

The Dutch Fertiliser Act (Mestoffenwet) and its Implementing Decree (Uitvoeringsbesluit Meststoffenwet) set out 'to guarantee fairness in the trade of fertilisers in order to protect users against inadequate fertilisers'.[116] They are broad in scope and apply to different types of fertiliser, setting the requirements for concentrations of heavy metals, organic micro-pollutants and pathogens.

As part of this second entry point, when recovered materials are used exclusively as fertiliser, it is not necessary to apply for an end-of-waste status. In the Netherlands, waste substances that are permitted under the Fertilisers Act are exempted from the obligations of the waste legislation, because they are covered by fertiliser product legislation instead.[117] These exempt substances, permitted to be used as fertiliser, are listed in Appendix Aa of the Implementing Decree.[118] Phosphates (such as struvite) and ashes recovered from sewage sludge can only be included in these exempt substances if they meet the definition of a fertiliser and the requirements set for fertiliser under Dutch law.

The Fertilisers Act distinguishes between different types of fertilisers: animal fertilisers, compost, other organic fertilisers and inorganic fertilisers. Organic fertilisers include sources based on organic matter, such as animal manure or compost. While inorganic fertilisers are defined as 'fertilisers in which the nutrients occur in the form of minerals obtained by extraction or by physical or chemical industrial processes'.[119] As such, although both phosphates and ashes recovered from sewage sludge come from an organic substance, they would fall under the definition of inorganic fertilisers because they are obtained by extraction or by physical or chemical industrial processes.[120]

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115 Dijkshoorn and de Best (2020) 15.

116 Ibid.

117 van den Dungen & van Schöll (2022) 4-6.

118 Uitvoeringsbesluit Meststoffenwet, Appendix Aa.

119 Staatsblad van het Koninkrijk der Nederlanden, Article 1(4).

120 Ibid; van den Dungen & van Schöll (2022) 6.

In order for recovered materials to achieve market entry as fertilisers, they need to meet a series of requirements: general requirements imposed on fertilisers, agricultural requirements and environmental requirements. The general requirements are outlined in Article 6 of the Fertiliser Act's Implementing Decree, addressing the purpose of the fertiliser (whether it feeds plants in the form of nutrients or is used to improve soil properties by supplying organic matter or increasing pH).[121] The agricultural requirements are outlined in Article 8 to 12 of the Decree, defining the composition of the fertiliser and setting the minimum amount of nutrients the fertiliser needs to supply.[122] Finally, the environmental requirements, in Article 13 to 15 of the decree, outline the maximum values of heavy metals and organic micro-pollutants contained in the fertiliser.[123]

For ashes recovered from sewage sludge, the maximum values of heavy metals are currently an obstacle to the admission of ashes as fertiliser and use of this entry point into the market. For struvite, since the beginning of 2015, the category 'recovered phosphates' has been included in Implementing Decree, meaning that recovered phosphates, such as struvite, can be traded in the Netherlands.[124]

b. Achievement of End-of-Waste Status

The second entry point into the Dutch market for product streams recovered from sewage sludge is the achievement of end-of-waste status. If choosing this entry point, a producer should first check in end-of-waste (herein: EoW) criteria have already been set at the EU or national level. At the EU level, such criteria exist, for example, for aluminium – but not for struvite or ashes. At the national level, such criteria are set by the Ministry of Infrastructure and Water Management (Dutch: Rijkwaterstaat) and already exist, for example, for recycling granulate. Both national and European regulations describe exactly which waste streams fall under the EoW criteria, what the processing should look like and what requirements the end-material needs to meet.[125]

There is no end-of-waste status for either struvite or ashes at either the European or Dutch national level. This means that their product status is assessed on a case-by-case basis by the Ministry of Infrastructure and Water Management.[126] A producer applies for this assessment via a declaration to the Ministry that their product meets the EoW criteria laid down in the EU's Waste Framework Directive. In the Netherlands, these criteria were transposed in the Environmental Management Act and will be in the new Environment

[121] Uitvoeringsbesluit Meststoffenwet, 13-15; van den Dungen & van Schöll (2022) 6.

[122] Uitvoeringsbesluit Meststoffenwet, 8-12.

[123] Uitvoeringsbesluit Meststoffenwet, 13-15.

[124] A. De Jong, and I. de Weerd, 'Struvite en de Wet [Struvite and the Law]' (Nutrient Platform NL, Report, October 2017) 2.

[125] Van den Dungen & van Schöll (2022) 4-5.

[126] Van den Dungen & Van Schöll (2022) 4.

and Planning Act that replaces it on January 2023. Seeing as this research was 'closed' on the 1st of July 2023 it does not cover the forthcoming transition to the Omgevingswet (scheduled to be introduced on the 1st of January 2024).

According to Article 6 (1) and (2) of the Waste Framework Directive (and Article 1.1, paragraph 8 of the Dutch Environmental Management Act), the criteria for achievement of product status are that:

- the substance or object is commonly used for specific purposes;
- there is an existing market or demand for the substance or object;
- the use is lawful (substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products);
- the use will not lead to overall adverse environmental or human health impacts.

When these four conditions are met, the material is no longer considered waste, meaning that rules that apply to waste no longer apply. However, when decided at the national level, the end-of-waste status is only applicable within the Netherlands and is only valid for a specific product location, application and customer base. This means that if a producer wants to use the substance in a manner that is different from that outlined in the initial application for product status, compliance with the EoW criteria needs to be demonstrated again in a new application. This number of administrative hurdles leads to free movement problems.

To move away from this cumbersome case-by-case decision-making, the Dutch 'Energy and Raw Materials' group is working to push through a nation-wide end-of-waste status for struvite, by sampling struvite from operating installations and analysing them to determine if the very strict quality requirements of the national law are met.[127]

c. Absence of Bioplastics

There could also be market entry for products recovered from sewage sludge outside fertilisers and agricultural application, for example through application as bioplastics. However, there are no end-of-waste criteria or additional requirements in the Dutch legislative framework for bio-char or platform chemicals that can be used to make bioplastics.

Despite this, the bioplastics market is growing in the Netherlands: five water boards, STOWA and several technology, waste and energy companies (Paques, HVC etc) have signed an agreement to build a pilot plant in Dordrecht for the production of PHBV, a fully degradable and sustainable bio-plastic.[128] PHBV is made from organic waste streams such as sewage sludge, industrial waste-

[127] Energie en Grondstoffen Fabriek (2020a).

[128] Energie en Grondstoffen Fabriek, 'Proeffabriek voor productie van uniek afbreekbaar bioplastic van start (Eng: Pilot plant for production of unique degradable bioplastic started)' (EFGF Website, October 2020b).

water and food waste. The pilot plant is intended to be a bridge to commercial production and application of PHBV.[129] Projects like this illustrate that there is movement of the plastics market towards the production and use of sustainable bioplastics. This will hopefully be supported by additional legislative clarity on end-of-waste for product streams used to make bioplastics, such as bio-char and platform chemicals.

6.3.6 Croatian Requirements for Products Made from Sludge

The Croatian legal requirements surrounding fertiliser products and bioplastics resulting from sludge recycling are discussed herein. Of the various product streams that can come from sludge, the Croatian legislative framework has expanded on the EU law only regarding compost made from sludge and specifically when it comes to land application. The relevant legislative documents are the Ordinance on Management of Sewage Sludge when used in Agriculture NN 038/2008,[130] the Ordinance on the Protection of Agricultural Land from pollution,[131] by the Ordinance on by-products and abolition of waste status,[132] and the 2020 Sludge Action Plan.[133]

The Croatian legislation in this sphere aims to respect the waste hierarchy by avoiding a purely energy recovery approach, but also implementing a complete ban on the use of untreated sludge on land where food is grown. Similarly to the Netherlands, Article 6 of the Croatian 2019 Ordinance on the Protection of Agricultural Land from Pollution (71/19) puts in place a complete ban on the use of sludge in agriculture in areas used for food production. This Ordinance replaced the 2008 Ordinance on Sludge Management from Wastewater Treatment Plants when sludge used in Agriculture (OG 38/08), which allowed land application if strict requirements on content of heavy metals and other pollutants were met.[134] Only stabilised sludge in which pathogenic organisms and other potential causes of diseases have been destroyed can be used in agriculture. According to the Ordinance, 'treated sludge' means sludge that has been subjected to biological, chemical or thermal treatment, long-term storage

[129] Ibid.

[130] Pravilnik o gospodarenju muljem iz uređaja za pročišćavanje otpadnih voda kada se mulj koristi u poljoprivredi NN 38/2008 (Eng: Rulebook on the management of sludge from wastewater treatment plants when the sludge is used in agriculture).

[131] Pravilnik o zaštiti poljoprivrednog zemljišta od onečišćenja NN 71/2019 (Eng: Rulebook on the protection of agricultural land from pollution).

[132] Pravilnik o nusprIizvodima i ukidanju statusa otpada NN 117/2014 (Eng: Rulebook on by-products and abolition of waste status).

[133] Ministarstvo Zaštite Okoliša i Energetike i Hrvatske Vode, 'Akcijski plana za korištenje mulja iz uređaja za pročišćavanje otpadnih voda na pogodnim površinama' (Ministry Report, March 2020).

[134] Comparing Article 4 of the 2019 Ordinance on the Protection of Agricultural Land from Pollution and Table 1.5 of the 2008 Ordinance on Sludge Management from Wastewater Treatment Plants when Sludge used in Agriculture, we can see the limits of heavy metals are different.

(at least six months) or some other procedure that significantly reduces decomposition and health hazards.[135]

When it comes to compost as a whole, not just compost containing treated sewage sludge, there seems to be an issue of legal coherence regarding the allowed content of heavy metals. These content limits are prescribed by the Ordinance on by-products and abolition of waste status (author: Ministry of Environmental Protection) and the Ordinance on the Protection of Agricultural Land from pollution (author: Ministry of Agriculture); however, the limits imposed are not the same.[136] Thus, it can happen that the content of heavy metals in compost meets the limit values according to the rulebook prescribed by the Ministry of Agriculture (can be used on agricultural land), but does not meet the limit values in the Ordinance prescribed by the Ministry of Environmental Protection (cannot be used on land for food production). In 2020, as required by the Croatian Ministry of Economy and Sustainable Development, an action plan for the disposal of wastewater sludge from WWTPs was created. The action plan is very detailed but has not yet been followed up with a national strategy for sludge management or the adoption of systematic practices in collaboration between the relevant institutional levels.[137]

The treated sludge and the material streams contained therein can reach end-of-waste status in Croatia. At the moment, the end-of-waste status can only be achieved on a case-by-case basis and mainly only for compost. There is no legislation or policy on bioplastics. Up until now (prior to 2023), after a company had obtained a permit for waste management and was able to start producing compost, if it wanted to sell the compost on the market, it could do so by registering in the relevant ministry's (MINGOR) register for abolition of waste status. The request had to include evidence that the compost produced is not harmful to the soil and that it meets the obligatory quality criteria, but it was possible.[138]

However, as of May 2023, the Croatian government has put forward a proposal for a new Fertiliser Products Act (P.Z.E. number 307), which makes some changes regarding end-of-waste for organic fertilisers and soil improvers, including compost and digestate.[139] The proposal is related to the EU's Fertiliser Products Regulation (No 2019/1009, FPR), which is discussed in detail in Section 6.3.1 of this chapter. To summarise, the Regulation regulates the placing on the market of fertilising products with the 'CE' marking, allowing them to be traded freely on the EU internal market. The FPR is directly

[135] Pravilnik o gospodarenju muljem iz uređaja za pročišćavanje otpadnih voda kada se mulj koristi u poljoprivredi NN 38/2008 (Eng: Rulebook on the management of sludge from wastewater treatment plants when the sludge is used in agriculture), Article 3(2).

[136] V. Petrović, 'Nova pravila za kompost i digestat? [New rules for compost and digestate?]' (Kružna Ekonomija Website, 22 February 2023).

[137] Domazet (2022).

[138] V. Petrović, 'Kompost – ukidanje statusa otpada, Dio 3 [Compost – End-of-waste status, Part 3]' (Kružna Ekonomija Website, 15th May 2017a).

[139] Prijedlog zakona o gnojidbenim proizvodima (Eng: Proposal of the law on fertilising products).

applicable in Member States, but since there is no legal framework in Croatia for fertiliser products that do not bear the 'CE' marking, the Ministry of Agriculture launched the proposal for the Croatian Fertiliser Products Act. It is intended to both transpose FPR rules on fertiliser products with a 'CE' marking and regulate fertiliser products that do not hold the 'CE' marking on the national market.[140]

As discussed in Section 6.3.1, the FPR prevents compost and digestate from obtaining the 'CE' marking, if they contain materials recovered from sewage sludge. The Ordinance on by-products and abolition of waste status (NN, 117/14) that has been in force until now allowed the use of materials recovered from sludge in compost and digestate, as long as it was not applied to land used for food production. Instead, it could be used in forests, parks, or for landscaping purposes.

If the new Fertiliser Products Act (P.Z.E. number 307) comes into force, this will no longer be possible, as explained in an online article by Petrović reviewing the legislation.[141] The proposed act states that both those organic fertilisers that do bear the 'CE' marking and those that do not, will be required to meet the same conditions for quality and type of raw material from which they are sourced. As such, 'neither compost nor digestate will qualify for use as organic fertilisers and soil improvers if they are made with materials from reprocessed sewage sludge'.[142]

Putting it in practical terms, this means that 'a municipal waste service company that composts sludge from its local wastewater treatment plant will no longer be able to use such compost even for landscaping its own park areas'.[143] This completely destroys any national market for these products and eliminates any national use possibilities for them. Essentially, condemning them to continue being sent to landfills. Petrović summed it up well in the review of the legislation, stating that 'it seems that with these proposals of the Fertiliser Products Act....we are once again implementing EU regulations and directives in the most unfavourable possible way for our [Croatia's] own economy'.

Despite the limits of Croatian legislation in this area, there are examples of positive practice for use of materials recovered from sludge. For example, in the city of Zadar, the company Eko Recens takes sludge from Zadar's WWTP and, using patented technology, mixes it with ash obtained by thermal processing of biomass to produce an innovative material used in construction (for the construction of embankments, roads, roofing, etc).[144]

To encourage the processing of sludge waste and the production of products, such as compost, it is necessary for the Ministry of Agriculture and the Ministry

140 Petrović A (2023).

141 Vesna Petrović is a waste management consultant and previously held the post of senior advisor at the Ministry of Environment and Energy; Petrović (2023).

142 Petrović (2023).

143 Ibid.

144 Domazet (2022).

of Environmental Protection to adopt a single harmonised document with clear rules and much simpler procedures. This is evident in several parts of the life cycle of the sludge, but is clearest here for products recycled from the sludge and in the landfilling restrictions discussed in Section 6.2.4 of the present chapter.

6.4 Analysis

The first objective of the present investigation was to map all open and closed loops within the life cycle of life cycle of life cycle of sludge materials, as they relate to the EU and national legislation and policy surrounding the circular economy. The framework against which these were evaluated are the EU's own circular economy objectives relevant to the recovery of organic matter from waste. These objectives are keeping materials in the economy for as long as possible (resource efficiency),[145] and their value as high as possible (waste hierarchy),[146] as part of the overarching goal of protecting a key product value chain: food, water and nutrients.[147]

The gaps in the life cycle become apparent when a 'traffic light system' is applied to map and comparatively review the existence of various legislative and policy tools at the EU level and the national level (in the Netherlands and Croatia). This is done below in Table 6. The first column on the left is labelled to correspond to the four most relevant stages of the sludge materials' life cycle (production of foodstuff, collection of unused foodstuff as waste, treatment and, finally, production of new products). The second column presents an extensive list of all the law and policy tools relevant to maximising the circularity of sludge materials' life cycle. The third column shows which of these tools can be found in law and policy at the EU level.

It should be noted that this is only a 'first check' of whether the tool is present and not yet an assessment of whether the tool *should* be implemented because it substantially contributes to the desired circular economy objectives. A green cell in the table indicates that the tool is present in the framework. A red cell indicates that the tool is not present, and a yellow cell indicates that the tool is present but with some limitations (i.e. it is not implemented in practice, it is only implemented by some municipalities, it only exists for some waste streams, etc). The same traffic light system is applied to the Dutch and Croatian legislative and policy frameworks in columns four and five.

145 Waste Framework Directive [2018] Article 11.

146 Waste Framework Directive [2018] Article 4.

147 Commission (2020a) 12.

Table 6:'Traffic light' table for law and policy tools for sludge materials

	Law and Policy Tools	EU	NL	CRO
Production (Foodstuff)	Targets/requirements on use of CRMs			
	CAP, greater competence sharing			
	CAP, precision farming (ex: nutrient stewardship)			
	Taxes on (raw) materials and products			
	Soft law agreements			
Collection	Landfill targets			
	Mandatory separate collection			
	Collection targets			
	Reporting			
	Monetary incentives			
Treatment	Targets for recycling and preparation for re-use			
	Licensing of waste-to-energy facilities only for non-recyclable waste			
	Permitting framework			
	Installation requirements for each treatment option			
	Inspections			
	Monitoring and reporting			
	Shipment regulation			
	Industry subsidies			
Products	End-of-waste criteria			
	Specific (separate) targets for re-use			
	Quality control for fertilizer products			
	Quality control for bio-based plastic products			
	CE marking			
	Other labelling			
	Reporting requirements			
	Markets for recycled raw materials			
	Green public procurement			
	Industry subsidies			

'Traffic light system' comparative review on the existence of various legislative and policy tools relevant to maximising the circularity of sludge materials' life cycle between the EU, the Netherlands and Croatia.

6.4.1 EU Level

There are only a few cases in the table where (at the same time/ in the same row) the EU calls for a law or policy to be implemented (green cell) and the Member States do not follow through (red cell/yellow cell).[148] This confirms that the legislative frameworks of both Member States are largely in compliance with the EU framework.[149] There are three tools that are counter to this: CAP precision farming; landfill targets; and market surveillance.

For 'CAP precision farming', Croatia was marked red due to the infrequent mention of precision farming in relevant legislative and policy documents at the national level, as well as the lack of projects set up to implement precision farming. 'Landfill targets' were identified only at the EU level and legislative bans on landfilling of sludge were identified at the national level (for both the Netherlands and Croatia).[150] However, both the Netherlands and Croatia are marked yellow in the table – because, although landfilling of sludge is banned, in 2020 the Netherlands landfilled 1.10 thousand tonnes of sludge and Croatia landfilled 0.71 thousand tonnes. The final tool that is green for the EU and red for both Member States is 'Market Surveillance', referring to Articles 16 to 29 in the market surveillance regulation. The present research did not identify any measures of market surveillance relevant to struvite, bio-char and ash product streams from sludge waste.

Despite compliance and harmonisation between different legislative levels, we can see many red cells for both the EU and Member States for many tools. They appear throughout, similar to VFG, but are most striking in the 'Treatment' and 'Products' stages of the life cycle. These red cells tell us, first of all, that the treatment and creation of products through sludge reprocessing could be addressed more thoroughly at the EU level.

The first barrier relevant to this is that there are not yet technical minimum standards for treatment activities, nor certainty on preferred treatment routes for sludge. Existing legislation, such as the EU's Sewage Sludge Directive, is understood and implemented by Member States in quite different ways. As mentioned in the chapter, the same provisions led to both Spain forbidding the incineration of sewage sludge and the Netherlands determining that all sewage sludge must be incinerated.[151] Although differing implementation if not in itself

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148 The only examples of this are for policy tools like 'exchange of information', which is encouraged at the EU level to facilitate the sharing of technical know-how, but is not actively carried out at the member state level with great intention.

149 Past studies on similar topics have found that despite accurate transcription, the practical application of legal requirements (particularly in Croatia) are in their infancy; Hrvatska AgencijI za Okoliš i Prirodu (2018) 47.

150 Law on Waste Management (ZGO) NN 84/2021, Article 55(1); Bianchini et al. (2016) 227.

151 Spain is one of the six Member States that choose to allow application of treated sewage sludge in agriculture, putting in place strict limit values for heavy metals and other pollutants, largely similar to the limit values set out in Annex IB of the Sewage Sludge Directive (86/278/EEC). The other five

a barrier (or problematic), the polar opposite implementations that run counter to the circularity objectives indicate that more clarity is needed at the EU level in this area. In order to ensure that Member States can correctly prioritise various environmental, circularity and health objectives when designing their sludge treatment systems. The second relevant problem to this is the end-of-waste status. Because there are no EU end-of-waste criteria for product streams coming from sludge (struvite, bio-char, ashes), it is left to the Member States to develop their own criteria. So far, this has caused lagging in the development of such criteria as Member States struggle to pioneer this technically and legislatively complex issue.

The third barrier is the absence of facilitating conditions like of waste-to-energy facilities only for non-recyclable waste. If the objective is to stimulate market uptake of treatment methods that are higher up on the waste hierarchy, then the less-preferred treatment methods need to be de-incentivised. One way to do this is by limiting use of less-preferred treatment methods to cases when all other treatment options have been exhausted (i.e. only for non-recyclable waste).

The lack of clarity present in all three of the listed challenges trickles down to treatment providers, for whom the relevant EU law (WFD, IED, BAT standards) focusses on large-scale treatment installations, while national law focusses on energy recovery installations. The lack of explicit mention of treatment methods focussed on recovery of organic matter creates uncertainty for market actors. With so much interplay between waste, product and material legislation, it is easy to invest a lot of money into a circular plant system that ends up being out of sync with the national and/or EU legislative frameworks, as seen in Case C-629/19 before the Court of Justice of the European Union.[152]

The fact that products made of materials that went through the full sludge life cycle are entering the market means that this type of circularity is possible, even under current legal frameworks. However, if the intention is for these practices to become more mainstream and commercialised at a higher level, then there need to be amendments or additions to the legislative and policy framework for clarity and coherence. This can be done in a heavy-handed way by including these treatment methods in EU legislation, be it the IED or the BAT. Another option is to address the clarity issue through an in-depth guidance document that would clearly set out the minimum standards for different treatment methods and the minimum quality control standards for the input materials and resulting material streams.

Finally, several of the legislative issues that came up in Section 6.2 of the chapter are related to what is defined as 'waste', what is defined as 'material' or 'product' and who is 'waste manager'. This is a long-standing debate in the fields of waste law and circularity. An expert from the Dutch Rijkswaterstaat, in

member states are Greece, Luxembourg, Ireland, Italy, Portugal and Spain; Aubain et al. (2002) 15, 21, 33; Dijkshoorn and de Best (2020) 3.

152 Backes & Kajić (2022) 248-258.

a preliminary interview that informed this research, suggested that if the legal definition of 'waste' was changed, then it is possible that we would no longer have control over the waste and product streams, because they would no longer be subject to the controls of waste legislation. The interviewee recommended that we continue to call discarded materials 'waste' in the legal context, but that we 're-frame' how we think of waste.[153] The idea is that if legal systems shift its awareness more towards feedback loops and therefore also the 'value' of waste in the wider societal narrative, it could be enough to reach our circularity goals without having to do away with the terminology and legal frameworks around 'waste'. Although this is an interesting idea, it is difficult to understand how we could re-frame the way we think about waste when the language we use continues to describe these materials as 'unwanted or unusable material, substances, or by-products'.[154]

A good example of how this could be done can already be found in relation to construction and demolition waste. Some streams of construction and demolition waste can be used as end-of-waste materials 'when necessary limit values for leaching pollutants are met, taking into account any possible adverse environmental and health effects', in some cases even without the operator using it having a specific 'waste processor' permit.[155] For example, asphalt waste can be used in road works without a specific permit under the Environmental Protection Act – 'provided that the requirements the Asphalt Circular of 15 July 1985 are met'. In this way, the protections of the waste law frameworks are still applied without the permitting restrictions, which stagnate the closing of target loops.

The flip side of this argument is that, instead of continuing on the same path and approach to our 'waste materials', it could be possible to limit the scope of waste law and focus on maintaining the environmental and health standards that are currently enshrined in waste law through material and product legislation.

Treatment (reprocessing) and creation of products are intrinsically linked, so another relevant issue here relates to product legislation. Reprocessing of VFG can result in three types of products: fertilisers, platform chemicals (bioplastics) and bio-energy (with bio-energy having been excluded from the scope of this study). As discussed in the VFG chapter, there is an extensive and comprehensive legal framework for fertiliser products, but the same type of framework does not exist for compostable, biodegradable and bio-based plastics at the EU level.

[153] Preliminary Interview with employee at the Directorate General for Public Works and Water Management, Rijkswaterstaat (The Netherlands, 17 February 2020).

[154] Oxford learners dictionaries, definition 'waste'.

[155] 'Some fractions of non-hazardous unpolluted C&D and certain other types of aggregates can be used as a substitute for primary raw materials without a specific permit under the Environmental Protection Act – provided the requirements of Statutory Order no. 1662 of 21 December 2010 are met.'; O. Hjelmar, et. Al., 'End-of-Waste Criteria for Construction & Demolition Waste' (Nordic Council of Ministers Report, 2016).

It is difficult to predict all the various products which material streams recovered from sludge could be made into. Some studies and interviewees have argued that instead of focussing on end-products, legislation and quality control criteria should be geared towards streams of recovered materials, such as the P, N and micronutrients themselves. Instead of developing a whole framework for bioplastics (such as the one that exists for fertilisers), then a whole new framework for whatever product becomes relevant next, the stage could be set for any number of products to be made using safe, quality controlled materials recovered from sludge. This is in addition to working on re-thinking conditions under which safe products could be produced from the given waste streams. In the case of sludge, this could be, for example, through the use of novel collection methods like source separated sludge or making a distinction between regular sludge from WWTPs and industrial sludge from the food industry (both in practical and legal terms).

Another issue is that there are no targets for reuse (the way there are, for example, for collection). Environmental targets at the EU level create urgency around the uptake of EU environmental standards and give EU institutions the grounds to directly follow-up with Member States on problems with regard to their achievement of targets.[156] The importance of these targets for sludge is the same as for VFG, discussed in the analysis section of the previous chapter.

Another area which Table 4 shows to be quite neglected is the start of the cycle – production of the original sludge foodstuff (i.e. agricultural production of vegetables, fruit and other plants) and the necessary conservation of virgin resources therein. This part of the cycle is the same for VFG and sludge, so the analysis from VFG chapter is applicable here to sludge.

6.4.2 Member State Level

In addition to needing to be better addressed at the EU level, the mostly red cells in columns four and five of Table 4 tell us that legislative guidance is either lacking or fragmented at the Member State level, too.

Overall, for both Member States, many tools are missing in the ‘treatment’ and ‘products’ phases of the life cycle. Neither Croatia nor the Netherlands make use of the following tools (relevant to sludge treatment and reprocessing facilities): targets for recycling and preparation for reuse; qualified licensing; permitting; installation requirements for each treatment option; recycling targets; inspections; monitoring of treatment; or industry subsidies. All these tools are marked red.

For ‘treatment’ in the Netherlands, the research identified that the majority of red cells are largely due to the ban on agricultural applications, which has forced all of Dutch sludge into incineration, lowering its potential value in the EU waste hierarchy. This seems to be based on an above-average prioritisation of the objective of safety. Evaluation of this approach always needs to be prefaced

156 Landfill Directive [1999]; Commission (2019c).

with the fact that, of course, public health and safety are always a necessary consideration when novel techniques or products are being introduced into the market, especially if they are in any way connected to food for humans (which these are). Despite this important note, it is also true that overprecaution in this regard can be stifling to innovation and other important objectives, such as those of resource conservation through circularity.

It is difficult to weigh when something is a well-founded precaution and when something is an overprecaution. In this case, it is helpful to look at the level of precaution exercised in the agricultural application of products recovered from sewage sludge and the precaution exercised in manure. Bio-technical studies on this topic have compared pollutants in these two streams and found that for many the difference is minor or that manure is actually more polluted. This is easiest to demonstrate with heavy metals. A 2014 study from Wageningen University found that nickel content of sludge was 1025mg per kgP, while for cow manure it was 1472mg per kgP.[157] Similarly, sewage sludge had a copper content of 12701mg per kgP, while cow manure had 14397mg per kgP .[158] Of course, there were also heavy metals (like zinc) where sewage sludge had the higher content (sewage sludge: 31166, cow manure: 25947mg per kgP), but this example is not intended to illustrate that there are *no* pollutants to be removed from sludge. Rather, many of the pollutants that we are cautious about with sludge are exactly the pollutants that we already apply in agriculture through manure. This further emphasises the importance of making a case for source separation of sludge (either in a decentralised or centralised manner).

This is just one example of a recurring trend in this area where the status quo is not as stringently regulated and allowed to continue freely, while novel methods are banned or severely limited due to precaution. It is not necessarily true that this is done intentionally to favour traditional actors and 'business as usual'; however, it is certainly a barrier to circularity. It is also just one example of an area in which regulation can be modified, not to decrease quality standards for novel, circular application, but rather to improve and heighten quality standards for traditional methods, thereby creating a more level playing field.

Meanwhile, for Croatia, the research identified that most of the 'treatment' gaps can be traced back to organisational issues and a core lack of the infrastructure needed for any far-reaching commercialisation of sludge treatment methods and products. There is still a very wide gap between the possible applications of these technologies and the Croatian reality.[159] Croatia needs to harmonise existing legislation to avoid confusing treatment operators and producers. This can be done by amending legislation to ensure harmonisation, but could also be facilitated by the creation of a body like the Dutch STOWA, the expertise and knowledge centre which represents the combined interests of the regional

157 T. Tervahauta, 'Phosphate and organic fertilizer recovery from black water'. Wageningen University, 2014, 68.

158 Ibid.

159 See Croatia sections of the present chapter, especially Sections 6.2.4 and 6.3.6.

water boards. A body like STOWA can help build knowledge around effective sludge management and align national law policy in this area with wider EU objectives, such as circularity and resource conservation. Finally, support in the form of economic and other incentives (taxes, subsidies, recycling quotas) would further help to establish a new recycling regime.[160] When providing funding in this hugely technical sphere, with so many possible paths and solutions, the EU should not approve funding for projects which do not fully carry out the management of sewage sludge in accordance with the EU's own waste and environmental law. Instead, the focus should be on the fact that the application of advanced sludge treatment solutions can also be a significant economic opportunity. These innovative solutions are drivers of the circular economy, but would also create opportunities to employ people in new sectors and create new value for industry and society at large.

For the 'products' phase of the life cycle, both Member States are lacking the following tools (relevant to products made from sludge): specific (separate) targets for reuse; quality control for bio-based plastic products; labelling; market surveillance; extended producer responsibility; reporting requirements; markets for recycled raw materials; green public procurement and industry subsidies. In addition to all these red cells at the Member State level, there is one tool with a yellow marking and two with a green marking. 'End-of-waste criteria for sludge materials' was marked yellow for both Member States because end-of-waste criteria have been developed for some of the materials that can be recovered from sludge (such as struvite) but not for many others. The green marking was given to 'quality control of fertiliser products' and the 'CE' marking because both are present for fertiliser and other agricultural products. However, the presence of these green cells relevant to fertilisers further underscores the absence of these tools for other valuable products that could be created from sludge materials.

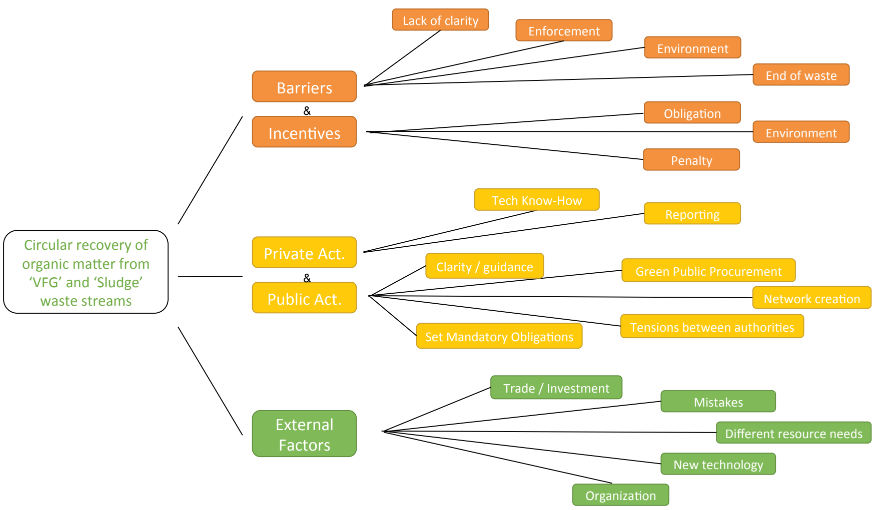
[160] Hukari, Hermann and Nättorp (2016) 1134.

CHAPTER 7

Empirical Research Results

This chapter presents the results of the qualitative empirical research conducted. The empirical segment of this research sought to explore the experiences of different relevant actors in bringing about a wider application of available biotechnological recovery methods and the wider use of the resulting recovered materials in products.[1] As a result of the axial coding on the first round of inductive open codes, four thematic areas arose: factors related to barriers and incentives, factors related to public and private actors and external factors (outside law and policy). Figure 10 shows a code tree of the thematic areas and some of the open codes that make them up.

Figure 10: Code tree of the thematic areas and some of the open codes that make them up



Some of the codes that emerged mirrored the law and policy tools identified in the doctrinal research. This was likely because the interview questions were derived in part from information obtained in the doctrinal research. However, a few new areas also emerged. These are discussed below, in the sections relevant to their respective stages of the material life cycle, alongside the findings from the deductive coding.

As a result of the deductive coding, for each law and policy tool in each phase of VFG and sludge life cycles, Table 7 shows the frequency with which EU, Dutch and Croatian interviewees called for reform (be that removing a barrier or introducing an incentive). A heat map (key shown in Table 8) was applied to draw attention to the tools that were brought up most frequently. Since there

1 For unclarities about the way the empirical methodology was applied see See section 2.3.2 on 'Empirical Analytic Strategy' in the Introduction and Methodology Chapter (Chapter 1).

were three EU interviewees and eleven interviewees for each of the two Member States, it was necessary to normalise the absolute values collected in the original data.[2] The absolute values can be found in Annex 1.

Combined with excerpts of quotes from the interviews, it becomes clear what some of the main barriers in the eyes of practitioners are, where and why they are occurring, as well as what they think can be done to overcome them.

Table 7: Frequency with which EU, Dutch and Croatian interviewees called for reform (be that removing a barrier or introducing an incentive)

	Law and Policy Tools	EU (3)	NL (11)	CRO (11)
Production (Food-stuff)	Targets/requirements on use of CRMs	1.00	0.45	0.36
	CAP, greater competence sharing	0	0	0
	CAP, precision farming (ex: nutrient stewardship)	0.33	0.18	0.09
	Taxes on (raw) materials and products	0	0.18	0
	Soft law agreements	0	0.18	0
Collection	Landfill targets	0.33	0	0.09
	Landfill tax	0.33	0.18	0.36
	Mandatory separate collection (VFG)	0	0.18	0.45
	Collection targets (sludge)	0.33	0.09	0
	Information	0	0.27	0.55
	Kerbside collection (VFG)	0	0.36	0.27
	Dropoff points (VFG)	0	0.36	0.27
	Waste collection charges (VFG)	0	0.36	0.27
	Industry subsidies	0	0	0
	Penalties for individuals	0	0.27	0.18
	Reporting	0.33	0.36	0.18

[2] Absolute values were converted into fractions and expressed as decimal values. This means that if, for example, 3 out of 11 Croatian interviewees mentioned a tool that tool was given the decimal value 0.27, because 27% of the Dutch interviewees mentioned that tool. However, if all 3 of the 3 EU interviewees mentioned a tool then that tool was given a decimal value of 1.0, because 100% of EU interviewees mentioned that tool. In this way the heat map colours are normalized across all interviewee groups, even though they are different in size.

Treatment	Targets for recycling and preparation for re-use	0.67	0.27	0
	Licensing of waste-to-energy facilities only for non-recyclable waste	0	0	0
	Permitting framework	0	0.27	0.64
	Min. treatment standards per waste stream	0.33	0.27	0.09
	Exchange of information	0.33	0.27	0.45
	Inspections	0	0	0
	Additional requirements for ABPs	0	0	0
	Quality criteria for compost and digestate	0.67	0.27	0.9
	Monitoring of treatment figures	0.33	0.18	0
	Industry subsidies 'recycling credit'	0	0.9	0.9
	Penalties	0	0	0
Products	End-of-waste criteria	0.67	0.64	0.73
	Specific (separate) targets for re-use	0	0	0
	Quality control for fertilizer products	0.67	0.27	0.18
	Quality control for bio-based plastic products	0.33	0.09	0.09
	CE marking	0	0	0
	Other labelling	0.33	0	0
	Extended producer responsibility	0	0	0

Table 8: Heat map key showing the absolute and normalised number of interviewees who mentioned a tool, as well as the colour assigned to them in Table 7

Absolute	Normalised	Colour
8-11	0.73 – 1.00	
4-7	0.36 – 0.72	
1-3	0.1 – 0.35	
0	0	

7.1 Conservation of Critical Raw Materials

The interview data revealed that the first part of the production cycle (conservation of critical raw materials used in the production of foodstuff) is not frequently mentioned by the interviewees. We can recall from earlier chapters that the critical raw materials (herein: CRMs) needed to produce the fertilisers and other agricultural products can be conserved not just through recovery and reuse of waste, but also by decreasing excavation of virgin materials and improving the efficiency of their use in farming practices.

There are already only a few identified law and policy tools in this area, and even those were not frequently called upon by the interviewees. Five Dutch and four Croatian interviewees called for legal targets/requirements on the use of CRMs, with one stating that '[binding targets to reduce mining of CRMs] would certainly also increase the pressure to take steps at the other end of the life cycle – when it comes to treatment and reuse of the waste streams'.[3] Nobody called for greater competence sharing relevant to the CAP, but two Dutch and one Croatian interviewee did refer to CAP obligations around precision farming (including nutrient stewardship) as important incentives toward better conservation of CRMs. In fact, an interviewee from the Dutch Ministry of Agriculture said that 'precision agriculture is something that is really booming at this moment, even with traditional mineral fertilisers'.[4] They went on to explain that in the experience of the ministry, 'Farmers really want to learn, not only because of the environmental benefits, but also from economic point of view. Farmers want to use the minimum amount of fertiliser possible, wasting as few of these resources as possible'.[5]

Only two Dutch interviewees discussed the impacts of taxes on CRMs and soft law agreements surrounding CRMs as important tools to improve conservation of these valuable materials. When it comes to taxes, the interviewee from the Ministry of Agriculture reflected on how taxing fossil-based fertiliser products could be an important incentive for conservation of CRMs, by encouraging a shift to renewable fertilisers. Although they said that it would be unlikely to be implemented now (in 2023) in the context of the energy crisis and the geopolitical situation with Russia.[6]

Beyond the deductive coding results, the open coding found that some external factors (outside of law and policy) play into conservation as well, an important one being: different resource needs. Different Member States have different resource needs; for example, the Dutch fertiliser market is already saturated with manure from the cattle industry. The expert from the Directorate General for Public Works and Water Management explained how the Dutch market places little value on recovered digestate and compost because they have so many cheap alternatives.[7] This leads to a lack of urgency for the uptake of CRM conservation efforts. The expert called for legislation or measures from above, from the government, to push for the conservation of these materials, not because 'companies can expect great rewards, but rather because it is a duty'. They further explained that this duty is an idea that is slowly developing but to which practitioners in the Netherlands are coming around.

3 Interview with the Croatian Ministry of Agriculture, (Croatia, 13 June 2022).

4 Interview with the Dutch Ministry of Agriculture, (The Netherlands, 9 September 2022).

5 Interview with the Dutch Ministry of Agriculture, (The Netherlands, 9 September 2022).

6 Interview with the Dutch Ministry of Agriculture, (The Netherlands, 9 September 2022).

7 Interview with Dutch Directorate General for Public Works and Water Management, Rijkswaterstaat (The Netherlands, 31 August 2022).

7.2 Collection

Collection is the part of the cycle that most effort has already gone into, on the part of law and practise. It is the part of the cycle with the highest number of identified law and policy tools and the one that the interviewees focussed on most. This is a difficult part of the cycle because a lot has already been done to make it more conducive to circularity and treatment for recovery, yet the best practices are still not settled, and uncertainty remains as to the best way forward.

Landfill targets were only mentioned once by a Croatian interviewee, while a landfill tax was mentioned twice by Dutch and four times by Croatian interviewees. Both mentions in the Dutch context found the landfill tax (which is no longer in force but played an important role in reducing landfilling between 1995 and 2012), to have been an important incentive for moving practices away from landfilling and towards other, more favourable collection and treatment options.[8] Meanwhile, of the four Croatian mentions, three were calling for the Ministry of Economic Affairs and Sustainability to bring into force the necessary implementing legislation for the landfill tax.[9] The fourth was with an expert from the Ministry of Economic Affairs and Sustainability who explained that the ministry largely agrees: '[the landfill tax] has been in the law since 2013, but there have been no changes regarding its implementation. We consider it to be the right tool, given that other countries who have it see significant improvements in alternative treatment routes'.[10] They went on to explain that, 'in all honesty, it's not been implemented in Croatia due to political dynamics. Every tax is difficult to carry out, and for this one there simply hasn't been enough political willpower.'[11] Failure to implement runs counter to national law, but the interviewee explained that 'they have not given up on the landfill tax, and they continue to support it as one of the important instruments through which landfilling can become the most expensive option – because without that the process will simply not move along'.[12]

Relevant to both sludge and VFG, there were several mentions of information (for consumers) and reporting (by waste collectors) as incentives for better collection. More information was called for as an important incentive three times in the Netherlands and six times in Croatia. It was interesting that this was also the case for sludge. It makes sense that consumers need to be informed about the collection of VFG waste because their ability to correctly sort their

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8 Interview with Dutch national knowledge centre for water boards, STOWA (The Netherlands, 30 August 2022); Interview with the Dutch Ministry of Infrastructure and Water Management (The Netherlands, 23 January 2022).

9 Interview with the municipality in Gospić (Croatia, 8 February 2022); Interview with Croatian Environmental Fund, FZOEU (Croatia, 31 January 2022).

10 Interview with Croatian Ministry of Economic Affairs and Sustainability, (Croatia, 7 June 2022).

11 Interview with Croatian Ministry of Economic Affairs and Sustainability, (Croatia, 7 June 2022).

12 Interview with Croatian Ministry of Economic Affairs and Sustainability, (Croatia, 7 June 2022).

waste plays an important role in the treatment and reprocessing of VFG that follows. However, consumers are not particularly involved with their wastewater once it leaves their toilets. Nevertheless, interviewees deemed it important that consumers are better informed of sludge treatment and reprocessing, both so they can get on board with pilot projects looking into alternative wastewater collection systems, but also mainly so they are not averse to market entry of products made from reprocessed VFG and sludge materials.[13]

Additional reporting was mentioned as an incentive for collection four times in the Netherlands and twice in Croatia. In all four mentions, it is clear that the idea is to make the reporting easy to share and compare. In the example given by the expert from the Dutch Ministry of Infrastructure and Water Management the purpose of this sharing and comparing was also, in part, to put municipalities and regions slightly into competition with each other. They explained how synthesising the municipal reporting data into a benchmarking database (which is continually updated and reviewed at networking sessions that bring relevant actors together) helped municipalities compare themselves with other municipalities of a similar population density and share solutions for more effective collection.[14]

When it came to collection methods for VFG, two Dutch and five Croatian interviewees called for stricter rules on mandatory separate collection, who deemed the lack thereof to be a barrier. Some Croatian institutions place the burden of separate collection entirely on the consumer, explaining how 'if the consumer does not separate properly, there is not much we can do with those streams except landfill or ship them outside of Croatia for incineration'.[15] The Dutch interviewees who called for stricter rules on mandatory separate collection also reflected on the role of penalties for consumers in this context. Three Dutch and two Croatian interviewees mentioned penalties for individuals when it comes to collection. The expert from the municipality of Zwolle explained that in their experience it is not as difficult as it seems to enforce penalties for inappropriately sorted waste (outside of a high-rise building context). In Zwolle, this was done by expanding the mandate of the waste collectors, who were required to 'glance inside the bin to see if the appropriate waste stream was inside', enter the address into the penalties system if something was incorrectly sorted and leave a sticker on the bin, informing the citizen that the waste was not collected due to improper sorting.[16]

The two kerbside collection and drop-off points tools for VFG were mentioned four times by Dutch and three times by Croatian interviewees. These

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[13] Interview with Dutch secondary raw materials producer (The Netherlands, 30 August 2022); Interview with a Croatian bio-plastic producer (Croatia, 29 November 2022); Interview with a Croatian waste management consultant (Croatia, 7 February 2022).

[14] Interview with the Dutch Ministry of Infrastructure and Water Management (The Netherlands, 23 January 2022).

[15] Interview with the waste service provider in Gospić (Croatia, 8 February 2022).

[16] Interview with the municipality in Zwolle (The Netherlands, 9 May 2022).

mentions were mainly to explain that improving access and convenience for citizens, through both collection methods, is an important driver for better collection (depending on the city and neighbourhood where either is implemented).[17] Beyond agreement on this, a lot of differing view-points between interviewees remain as to the best way forward when it comes to VFG collection. This is in line with the back-and-forth around collection described in the VFG chapter on the example (of (some municipalities) in the Netherlands, wherein there is continued change in practice around preferred waste collection method –plastic was first collected with residual waste, then separated out by the consumer and now integrated back in again (leading to dirty factions mixing with clean ones). Although there are technical justifications for this change, this type of back-and-forth about how waste should be collected highlights an underlying lack of certainty over the 'best' way to collect and, therefore, also the 'best' way to treat collected waste. This also came through in the interviews, with one Dutch and two Croatian interviewees defending the importance of separate VFG collection at the doorstep, and others saying it is no longer a collection method that aligns either with the treatment methods that follow or the economic reality of markets for products recovered from the waste.

For example, the expert at the Čakovec waste service provider explained that though they currently separate many waste fractions, including VFG, they have learned that this is not economically profitable for them because of the absence of a strong market for the end-products.[18] The expert said, 'Circular management is expensive, pyrolysis is expensive. Much of the treatment is held up by human labour, which is also expensive…so sorting at the doorstep, sending out trucks on separate collection days, just so all that waste still has to pass through a machine to be re-sorted…it just doesn't make sense.'[19] In their opinion, the only argument in favour of doorstep separation is that it develops the consumers' awareness of waste as a resource and as an important source of raw materials, and it also heightens the importance of thinking more consciously about the raw materials we extract from nature in order to create products.

Meanwhile, adjustments to waste collection charges were mentioned four times by Dutch and two times by Croatian interviewees. All the mentions were related to VFG, and most focussed on waste collection charges, such as pay-as-you-throw. Positive mentions calling for pay-as-you-throw came from smaller municipalities, while larger cities and ministries tended to favour other types of waste charges. For example, the interviewee from Den Haag explained that they preferred the idea of a system in which waste collection charges could

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17 Interview with the municipality in Den Haag (The Netherlands, 11 May 2022); Interview with the municipality in Zwolle (The Netherlands, 9 May 2022); Interview with the Dutch Ministry of Infrastructure and Water Management (The Netherlands, 23 January 2022); Interview with the waste service provider in Zwolle (The Netherlands, 9 of May 2022); Interview with a local waste service provider in Čakovec (Croatia, 9 February 2022); Interview with the waste service provider in Gospić (Croatia, 8 February 2022).

18 Interview with a local waste service provider in Čakovec (Croatia, 9 February 2022).

19 Interview with a local waste service provider in Čakovec (Croatia, 9 February 2022).

be amended to suit the needs of different cities. For example, Den Haag is concerned that the problems it already faces around citizen compliance with waste separation would only increase if citizens were also asked to pay for the residual waste they throw away. Instead, they suggest a system in which citizens are rewarded for the waste streams they separate (ex: every kilo of separately-collected, clean plastic brought in gives the citizen a reward of 10 cents, or something of this nature). This is also difficult to enforce, but the interviewee explained that if we are looking at creating the ideal waste system, then this would be a better way to go.

When it comes to collection targets relevant to VFG, one was mentioned at the EU level and one by a Dutch interviewee. The EU interviewee explained that feedback they had received on existing collection targets was that future amendments to the targets need to be based on quality not quantity (as is the case with the current targets).[20] Quality assurance is low in the current legislation, so the ability to treat and recover from waste streams is also low, which is why more research and attention need to go towards defining possible quality targets.[21] This viewpoint was confirmed by a waste service provider in Den Haag, where the interviewee explained how municipalities mainly think in volume or sorting rather than quality, and this needs to change if the circularity objectives are to be met.[22]

Sludge collection was a much less straightforward topic. The targets for sludge collection and novel collection methods were mentioned by one EU interviewee and one Dutch interviewee. The EU interviewee mentioned possible sludge collection targets in a distant utopian future, 'where such a measure would be measurable and enforceable'.[23] However, the Dutch interviewee had high hopes for novel ways of collecting sludge, at least for the Netherlands. This expert, from the Ministry of Agriculture, explained that they do not see dry toilets, e.g. compost toilets, as a plausible solution for most city-dwellers; however, they did think that toilets that source separate the urine fraction and the faeces fraction could be implemented in newly built large buildings and also at outdoor public events (such as markets and festivals).[24] They explained that the implementation of this technology in household is still distant, but that it is something the Dutch water boards are already looking into – and already implementing in the livestock industry.[25] Some studies have shown that source separation into these two fractions can improve the recovery of some nutrients and other organic matter.[26]

[20] Interview with member of the EU Environmental DG 'from waste to resources' (Digital, 7 March 2023).

[21] Interview with member of the EU Environmental DG 'from waste to resources' (Digital, 7 March 2023).

[22] Interview with the waste service provider in Den Haag (The Netherlands, 11 May 2022).

[23] Interview with member of the EU Environmental DG 'from waste to resources' (Digital, 7 March 2023).

[24] Interview with the Dutch Ministry of Agriculture, (The Netherlands, 9 September 2022).

[25] Interview with the Dutch Ministry of Agriculture, (The Netherlands, 9 September 2022).

[26] M.E. Koulouri, et. Al., 'Source separation of human excreta: Effect on resource recovery via pyrolysis.' Journal of Environmental Management 338 (2023): 117782.

To underline the difficulties around the collection of these waste streams, the open coding of interviews found a fear of making mistakes. It was mentioned by two Croatian interviewees and three Dutch interviewees. The hesitancy is best summed up in the interview with an expert from the Den Haag municipality, who said that any mistakes (such as collected streams not being clean enough to use in treatment facilities to create products) will lead to hesitancy in the future – both on the part of treatment companies and consumers.[27] They went on to say that 'the nature of the topic requires a consistent policy goal that is long-term, but this is difficult to achieve when the science and best practices are not fully settled matters and when there are so many differences and needs at the local level'.[28]

7.3 Barriers to Treatment

When looking at the results of the heat map on page 200 of the present chapter, we can see that the challenges facing Croatia and the Netherlands, regarding treatment of VFG and sludge waste streams, are not that different. Of course, the practical situation in these two countries is different and the Netherlands is ahead of Croatia when looking at the amounts of waste streams that are being treated and reprocessed, since it was able to reduce landfilling early on and focus its attention on incineration and alternative treatment methods. Despite this, when looking at the issues raised by interviewees, we can see that the actors working on this issue at all institutional levels have similar focus areas and similar blind spots.

For example, both EU, Dutch and Croatian interviewees focussed on recycling/reuse targets, permitting frameworks and exchange of information as important issues. Targets for recycling and preparation for reuse came up in two EU interviews and three Dutch interviews. They all broadly agreed that recycling targets for all waste streams incentivise Member States to improve their treatment practices, and that adding reuse targets for VFG and sludge would do the same for these two waste streams. One Dutch interviewee broadened the topic to explain how other regulatory requirements need to be put in place to help installations gear their processes towards broader, national recycling targets.[29] The expert from the Ministry of Agriculture used the example of sludge treatment installations, explaining that rules around the water that Dutch installations can discharge into surface waters needs to be stricter. This would encourage better treatments and make recycling targets easier to achieve. They explained that the water that is currently being discharged, at the cleanliness percentage currently required by law, still contains a lot of nutrients that end up discharged into Dutch surface waters. If this cleaning percentage was

[27] Interview with the municipality in Den Haag (The Netherlands, 11 May 2022).

[28] Interview with the municipality in Den Haag (The Netherlands, 11 May 2022).

[29] Interview with the Dutch Ministry of Agriculture, (The Netherlands, 9 September 2022).

increased, to require an 85-90% reduction in nutrient content of the water, then the recovery of nutrients would be significantly promoted.[30]

These types of regulatory requirements set at the national level could help achieve recycling and reuse targets, as well as EU objectives around circularity. They could even be included in the 'minimum treatment standards per waste stream'. This tool was brought up by one EU, three Dutch and one Croatian interviewee. All experts who mentioned it seemed to agree that these standards, which set the level of treatment for each respective waste stream, were needed to ensure that waste was not treated on a lower-than-desirable level of the waste hierarchy. The EU interviewee explained that harmonising these standards is an aim of the EU, which is also reflected in the CE Action Plan and the WFD. However, it is an aim that will take time because of the 'diverse waste management landscape across EU Member States'.[31]

One Dutch interviewee also explained how it is important for minimum treatment standards to become more robust as collection practices change and grow.[32] They said that collection in cities is increasing and 'in the coming years it will continue to increase, so we cannot expect those streams to be completely clean, completely without contaminants'.[33] As such, he suggested increasing the minimum standards specifically for streams that are suspected to have additional contaminants (such as additional pre-treatments), rather than limiting or banning the use of these streams overall.[34] This example highlights how the same tool can be used to both improve circularity (respecting the waste hierarchy) and set the necessary safety standards – putting two (often competing) objectives in harmony with one another.

If targets and minimum treatment standards are to be met, a clear permitting framework is required, which is likely why this was the most frequently mentioned tool – with three Dutch and seven Croatian interviewees calling for changes in the EU or national permitting framework. The issue raised most frequently was the difference in permitting requirements for recycling/recovery companies compared to fertiliser companies using virgin resources. The matter is summarised for the EU level by a Croatian expert from the Croatian Ministry of Economy and Sustainable Development: Recycling and recovery companies, labelled as 'waste management' [under Article 3 and 15 of the Waste Framework Directive] must follow much stricter rules than fertiliser companies that use virgin resources, such as phosphate rock. This already creates a barrier before we even move into national permitting requirements.'[35]

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30 Interview with the Dutch Ministry of Agriculture, (The Netherlands, 9 September 2022).

31 Interview with member of the EU Environmental DG 'From waste to resources' (Digital, 7 March 2023).

32 Interview with Dutch Directorate General for Public Works and Water Management, Rijkswaterstaat (The Netherlands, 31 August 2022).

33 Ibid.

34 Ibid.

35 Interview with Croatian Ministry of Economic Affairs and Sustainability, (Croatia, 7 June 2022).

The same sentiment was echoed in relation to minimum standards by the Dutch expert from STOWA (the Dutch national knowledge centre for water boards): ‘What I really find interesting is the difference in the level of scrutiny of the minimum standards applied to the currently predominant mineral fertilisers, compared to fertilisers and soil improvers made from recovered materials.’ What both experts are referring to is the imbalance currently present in the permitting framework for actors using recovered materials (circular actors) and actors producing more traditional fertiliser products (traditional actors). The imbalance arises due to the increased level of safety concerns around the former, because of their novelty. This touches upon an issue identified in the doctrinal research too – the difficulty in weighing when something is well-founded precaution and when something is overly precautious.[36]

Another frequently mentioned tool was quality criteria for compost and digestate. This tool relates to the end-requirements for material streams after treatment. The tool was mentioned by two EU, three Dutch and one Croatian interviewee. One Croatian and one Dutch expert expressed concern about setting the ‘right’ limits in quality criteria, to ensure maximum safety and minimal harm to the environment and human health. The Dutch STOWA expert said, ‘All water authorities want to produce the right materials after treatment and without environmental pollution, but they need clarity on what is needed and what can be done realistically. Regulation needs to be ready for that in a short time’. Meanwhile, the expert from the Dutch Ministry of Infrastructure and Water Management was confident that the quality standards the Netherlands is developing, and has developed, are dependable because of the ‘long-standing and complex risk assessment process that preceded them’.[37] He only added that these quality criteria and standards need to be present at the EU level as well, to ensure maximum safety across the Union. This sentiment was echoed in one EU interview as well.[38]

Harmonisation across the Union can also be facilitated through exchange of information, a tool that was mentioned by one EU, three Dutch and five Croatian interviewees. At the EU level, the interviewee from the European Compost Network highlighted how information exchange between the EU and local authorities needs to take place in order to coordinate local plans and EU circularity objectives. They gave the example of green waste, stating that in addition to VFG ‘waste from green areas in cities is an important source of organic resources’. The vision is ‘not to plant trees or shrubs in cities just for the sake of using them as bio-resources, but if cities already have them to ensure that they are used – a multi-objective approach. This is increasingly recognised as important for heat regulation, water, dust absorption etc, but it would also create a clean, critical mass for the types of treatment operations that are also needed

36 See 6.4.2 titled ‘Member State Level’ in the Sludge Chapter (Chapter 6).

37 Interview with the Dutch Ministry of Infrastructure and Water Management (The Netherlands, 23 January 2022).

38 Interview with member of the European Compost Network (Digital, 9 March 2023).

to treat other waste streams, such as VFG'.[39] They felt it was the role of the EU to be in cooperation with local governments, to achieve these multi-objective approaches.

All five Croatian actors who called for information exchange gave examples from outside VFG and sludge waste streams of previous cases where information exchange occurred (between national authorities of different Member States or between EU and Croatian authorities) and facilitated modernisation of treatment methods in Croatia. The interviewee of a Croatian bio-plastic production company highlighted that this is not yet happening at the national level when it comes to waste streams such as VFG, leaving it 'to individual companies to gather their own know-how and work within a legal system created for more traditional treatment methods'. It is also apparent that different regions in Croatia have very different rates of recycling and treatment for reuse. The Dutch expert from the Directorate General for Public Works and Water Management gave an example of how exchange of information was harnessed in the Netherlands to encourage healthy competition and efficient advancement of treatment methods.

They described the household waste benchmarking system and accompanying workshops organised by the Directorate General. Four times a year, as many participants as possible are invited to join these workshops, which are currently attended by representatives from about half of Dutch municipalities as well as their cooperating waste services (ROVA, Haagse Milieuservices etc).[40] The sessions kick off with some general waste-related topics and presentations on novelties in the sector. This is followed by a comparison of the waste benchmarking figures collected for all Dutch municipalities and waste services. The figures are based on statistics that participants collected themselves about their own waste services. This leads to a lot of discussion around the challenges and opportunities that become apparent from the figures – taking place in groups which are divided on the basis of how urban or rural municipalities are.[41] The division is necessary because of the differences in waste challenges faced by urban and rural municipalities. The achievements of municipalities, as presented in these figures, are then also made publicly available online. This means that if certain municipalities do not do as well and receive a 'red' marking in publications, it opens them up to questions and critique from citizens and fellow regional municipalities. This creates pressure through 'naming and shaming', which the expert explained 'really does a lot to influence municipalities to get on track to achieve regional and national objectives'.[42]

This type of exchange of information is only possible if consistent and complete monitoring of treatment figures is collected. This tool was only

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39 Ibid.

40 Interview with Dutch Directorate General for Public Works and Water Management, Rijkswaterstaat (The Netherlands, 31 August 2022).

41 Ibid.

42 Ibid.

mentioned three times, by two interviewees in the Netherlands and one in Croatia. While the Dutch interviewees reflected positively on the amount of reporting around VFG and sludge treatment geared towards circularity objectives, the interviewee from the Croatian Ministry of Economic Affairs and Sustainability explained that while a lot of statistics are collected and reported, more could be done in the monitoring follow-up.[43] Additionally, they highlighted problems around harmonisation of treatment data across different data bases at the national level. They explained how the Ministry's own institute for environmental and nature protection has a database relevant to collection and treatment, which is continually being updated but 'never quite fast enough'.[44] They describe how they know of situations where 'applicants had to submit the same data points into two, or sometime three, separate systems'.[45] As a solution to this, the interviewee said that 'all this needs to be brought together in one database, so that applicants do not have this administrative burden, but so that all these different institutes can pull the information they need from a single system. But this is difficult in a system which was until recently relying on handwritten application sheets. We hope that a newer system, such as e-ONTO, will speed up and unify this process'.[46]

One Dutch and one Croatian interviewee also mentioned 'industry subsidies'. The Croatian interviewee from a compost production company said that financial support in the form of subsidies is always what helps them take on new challenges with novel technologies.[47] Meanwhile, a Dutch interviewee explained that they were not in favour of subsidies because they believe they cause strange effects on the market, distorting the natural course of supply and demand and potentially leading to financial trouble in the future.[48]

The blind spots, tools that were not mentioned, align with the gaps identified in the doctrinal traffic light research results. Five policy tools that were not mentioned in any interviews for any waste stream were 'licensing of waste-to-energy facilities only for non-recyclable waste', 'inspections', 'additional requirements for ABPs'[49] and 'penalties'.

Beyond the results of the deductive coding, the open coding found two additional factors that limit treatment options, specifically in Croatia. These were logistical/organisational issues and tensions between regional and local authorities. According to the interviewee of the local waste service provider in Čakovec, the lack of the necessary infrastructure is central to the problems related to the

[43] Interview with Croatian Ministry of Economic Affairs and Sustainability, (Croatia, 7 June 2022).

[44] Ibid.

[45] Ibid.

[46] Ibid.

[47] Interview with Croatian waste treatment plant (Croatia, 1 June 2022).

[48] Interview with Dutch engineering consultancy firm (The Netherlands, 27 September 2022).

[49] 'Additional requirements for ABPs' were brought up in several interviews as an important matter to keep in mind when talking about alternative types of treatment, like vermicomposting and BSFG treatment. However, no interviewee called for changes in the regulations in this area.

circularity of valuable organic resources in Croatia. They explained that 'Croatia has the problem of not having incineration. According to our legal framework of preferred procedures, energy recovery is higher than landfill. However, since we do not have that infrastructure, and we do not have a centre for waste disposal, we rely a lot on the landfill. Within that situation, large-scale application of any method beyond incineration seems like utopia.'[50] They went on to explain that 'the problem is again our weak financial potency. European funds are available to us, but the Croatian administration is slow in making adjustments; waste disposal centres are developing very slowly, there is a lot of wandering around in setting up the legislative support…the dynamics of development are not set according to the best LSGU, nor according to the worst, but according to some middle ground. And so, more advanced regions such as Međimurje are condemned to wait and struggle within the framework that exists'.[51] The interviewee went on to describe in detail how the tensions between authorities play out and hamper the circularity transition, specifically in regard to waste treatment. These details are very situation-specific and would not be generalisable or helpful to other Member States; however, it is important to note that they are significant problems in various regions of Croatia and in the governance landscape overall.

This interview also described a host of issues between the regional and local governments, as well as the European Fund at the national level, which led to increases in administrative burdens and hampered the improvement of treatment options accessible for VFG specifically.[52] The political tensions between authorities is connected to the lack of infrastructure, because one fuels the other in a vicious circle. The problem of a lack of infrastructure was echoed by the interviewee at the Ministry of Economic Affairs and Sustainability, who said that 'installations, all kinds of waste management and treatment installations – that's really what we're missing'.[53] They also explained the importance of the Fund's role in coordinating efforts around developing installations with EU objectives and financing. They described how it sometimes 'seems that it would be better for more criteria around installations to be developed at the EU level, but then we think…maybe these are things that are better sorted out at the national level, in our own Fund, given that we're familiar with the situation in the country'.[54]

The issue with the Fund and supporting infrastructure is supported by the literature, where the problem was summarised by Petrović in 2023: 'The

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50 Interview with a local waste service provider in Čakovec (Croatia, 9 February 2022); Interview with the municipality in Čakovec (Croatia, 9 February 2022).

51 Interview with a local waste service provider in Čakovec (Croatia, 9 February 2022).

52 'They were looking for some kind of proof of quantities, unification. They were looking for some things which we simply stumbled on in the amount of documentation. Basically, documentation fatigue. I'm not saying there shouldn't be documentation, but it can be more flexible to local specific situations'; Interview with a local waste service provider in Čakovec (Croatia, 9 February 2022).

53 Interview with Croatian Ministry of Economic Affairs and Sustainability, (Croatia, 7 June 2022).

54 Ibid.

Environmental Protection Fund should continue to coordinate the financing of the system through EU funds, but instead of waste containers, it must first call for tenders for infrastructure – recycling centres, sorting plants, composting plants and so on'.[55] The point continually highlighted is best framed as a question: 'What good are bins for biodegradable waste if you don't have a composting plant in which to process the collected bio-waste?'[56]

7.4 Creation of New Products (and Markets)

The points of attention and blind spots remain very similar for actors across institutional levels in the 'creation of new products' part of VFG and the sludge life cycle, as well.

7.4.1 End-of-Waste Criteria

End-of-waste criteria was by far the most frequently mentioned tool here, with two EU, seven Dutch and nine Croatian interviewees calling for changes in the current end-of-waste criteria frameworks. Most of the interviewees in both Member States called for further guidance from the EU level. Some called for criteria for materials contained within VFG and sludge to be established at the EU level, but most just called for clarity to be provided on how the criteria should be set at the Member State level. Interviewees from practice particularly, such as the expert from a Dutch engineering consultancy firm, called for further clarity on the relationship between end-of-waste and the REACH Regulation.[57] This demonstrates that precisely the companies that are at the forefront of this transition find the existing legislative frameworks confusing. The expert from a Croatian consultancy company on bio-resources suggested the creation of a monitoring team for end-of-waste criteria developed at the Member State level, with the hope that such a body would improve harmonisation and reduce some of the confusion around the process.[58] Of course, this could only function alongside continued work of the development of PFCs and CMC criteria in the FPR and the expansion of relevant dossiers under REACH.

Another matter that was raised by most interviewees about end-of-waste was the administrative burden surrounding it. First, at the institutional level (in that it takes a long time for the authorities to develop and approve a dossier for a specific product stream), but then also at the producer level (in that it is a huge burden on the finances of a company and time to achieve the end-of-waste status of their product). This issue was summarised by an expert from the Dutch STOWA who said 'just look at how long the procedure for struvite was,

55 Petrović (2017a).

56 Ibid.

57 Interview with Dutch engineering consultancy firm (The Netherlands, 27 September 2022).

58 Interview with employee at a Croatian bio-resource Consultancy (Croatia, 31 May 2022).

how long we were developing that dossier. That is terrible. And then we want to have showcases that demonstrate to public parties that we have this very good, valuable material available…but any energy we manage to gather around getting parties involved in this just flows away – because they have to deal with all the paperwork'. Although this is certainly something that hampers the transition, it does not seem that too much can be done to lessen the burden on public parties – the checks and permitting processes need to be in place to ensure compliance with the safety standards for product streams.

Several interviewees also mentioned that end-of-waste criteria at both the EU and national levels will require continued maintenance even after their initial development and implementation. The expert at the Dutch Ministry of Agriculture explained how criteria developed today will drive the better use of resources from relevant waste streams, but that when new possibilities occur 'say in 10 years, legislation that is now innovative will become cumbersome because we will see new possibilities. So, rules that currently seem to be opening the sector will actually begin to hamper it'.[59] As such, it will remain important that Member States stay up to date on innovation in this area and changing perceptions around these material streams. Although this will benefit circularity, it will be a strain on legal certainty, as standards continue to change.

7.4.2 Quality Control – Fertiliser Products

The second-most-frequently-mentioned tool was 'quality control for fertiliser products', mentioned by two EU, three Dutch and two Croatian interviewees. The interviewees highlighted three issues: confusion at the national level; conflicts between safety and circularity; and varied standards for traditional and circular actors.

Confusion at the National Level

Confusion at the national level relates to how EU Member States sometimes implement the same EU directives in opposing ways – as in the example of the Sewage Sludge Directive (which led to both Spain forbidding the incineration of sewage sludge and the Netherlands determining that all sewage sludge must be incinerated).[60] This leads to some fragmentation at the EU level when it comes to achieving objectives (both circularity and single market); however, interviewees at the EU level argued that this is precisely the point of using a directive rather than a regulation in certain fields. Explaining that 'when conflicting follow-through like this occurs it is often because of the different cultural,

[59] Interview with the Dutch Ministry of Agriculture, (The Netherlands, 9 September 2022).

[60] Spain is one of the six Member States that choose to allow application of *treated* sewage sludge in agriculture, putting in place strict limit values for heavy metals and other pollutants, largely similar to the limit values set out in Annex IB of the Sewage Sludge Directive (86/278/EEC). The other five member states are Greece, Luxembourg, Ireland, Italy, Portugal and Spain. EC, 'Disposal and recycling routes for sewage sludge' (Part 2 – Regulatory report), p. 15, 21, 33.

historical and legislative approaches of different Member States' – and the EU legislative landscape makes space for these differences.[61] In the given sewage sludge example, the extra caution on the Dutch side could come from past experiences where it was felt that the balance scale between an opposing objective and safety tipped too far towards the opposing objectives, risking safety to a degree the national institutions are no longer comfortable with.[62]

However, there are also times when it is clear there is confusion about what objectives to prioritise among Member States themselves. An example of this can again be taken from fertiliser products recovered from sewage sludge where, as discussed in Section 6.3.1, the FPR prevents compost and digestate from obtaining the 'CE' marking if they contain materials recovered from sewage sludge. In transposing the FPR, Croatia's newly proposed Fertiliser Products Act (P.Z.E. number 307) will now prevent such use of sewage sludge not only for compost and digestate with a CE marking, but any compost and digestate – even that which was only intended for national use on non-agricultural land, such as forests, parks, or for landscaping purposes.[63]

In practical terms, this means that 'a municipal waste service company that composts sludge from its local wastewater treatment plant will no longer be able to use this compost even for landscaping its own park areas'.[64] This entirely destroys any national market for these products and eliminates any national use possibilities for them. Essentially, we condemn them to continue to be sent to landfills. Petrović, consultant and previously adviser to Croatia's Minister of the environment and energy summed it up well in her review of the new legislation, stating that 'it seems that with these proposals of the Fertiliser Products Act…we are once again transferring EU regulations and directives in the most unfavourable possible way for our [Croatia's] own economy'.

The FPR itself states that compliance with the Regulation 'should not apply to products which are not CE-marked when made available on the market', such as those sold on the national market.[65] In this way, the regulations makes space

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61 Interview with member of the EU Environmental DG 'sustainable products' (Digital, 7 March 2023).

62 Ibid.

63 Petrović (2023).

64 Ibid.

65 Regulation of the of the European Parliament and of the Council (EU) 2019/1009 laying down rules on the making available on the market of EU fertilising products [2019] OJ L170/1, Perambulatory Clause 5; 'Contrary to most other product harmonisation measures in Union law, Regulation (EC) No 2003/2003 does not prevent non-harmonised fertilisers from being made available on the internal market in accordance with national law and the general free movement rules of the Treaty on the Functioning of the European Union (TFEU). In view of the very local nature of certain product markets, this possibility should remain. Compliance with harmonised rules should therefore remain optional and should be required only for products, intended to provide plants with nutrient or improve plants' nutrition efficiency, which are CE marked when made available on the market. This Regulation should therefore not apply to products which are not CE marked when made available on the market.'

for 'the very local nature of certain product markets'.[66] It is unclear why Croatia took such a precautious approach, even around non-agricultural land in the proposed national act, but it certainly demonstrates confusion at the national level as to the balance of objectives around safety and circularity. Especially when local governments and waste service providers have already invested considerable effort to develop compost and digestate production and could find local use for these product streams.[67]

Conflict Between Safety and Circularity

The varied interpretation and sometimes confusion at the national level (such as that demonstrated in the above two examples) is indicative of conflicts between different public interest objectives (human, animal and plant health, safety and the environment). Several interviewees also pointed to this, saying that the tension is present not only between what public interests different Member States place an emphasis on, but also among, ministries within Member States. The expert from the local government in Gospić in Croatia explained that from their perspective the ministries of environment place a greater emphasis on the environmental objectives (and greater circularity within that).[68] While the Ministry of Agriculture is often left being 'the bad guy', exercising more caution and having to place greater emphasis on public safety and health.[69]

The expert from the Dutch Ministry of Agriculture said that this perspective is perhaps overly simplistic and that it depends on who you speak to within the different ministries.[70] They feel it is the job of the Ministry of Agriculture to balance these different objectives, because on the one hand the ministry 'want(s) farmers to have the ability to use these resources in fertilisers in the agricultural sectors, but we are also the ministry in charge of food quality. So, of course, you want products that are not contaminated with pollutants and that consider public health and safety'.[71] No matter which public authority or institutional level is in charge of balancing this conflict, it remains true that it is present as a barrier to a smooth transition for resources recovered from VFG and sludge.

Disproportionate Standards for Traditional and Circular Actors

Although it was already discussed in Section 7.4 on 'Barriers to Treatment', it is important to note that disproportionate standards for traditional and circular actors are also relevant in the 'products' part of the life cycle. As cited before, the Dutch interviewee from STOWA commented that 'what I really find interesting is the difference in the level of scrutiny on the minimum standards applied to

66 Fertilizer Product Regulation, Perambulatory clause 5.

67 Interview with a local waste service provider in Čakovec (Croatia, 9 February 2022).

68 Interview with the municipality in Čakovec (Croatia, 9 February 2022).

69 Ibid.

70 Interview with the Dutch Ministry of Agriculture, (The Netherlands, 9 September 2022).

71 Ibid.

currently predominant mineral fertilisers, as compared with fertilisers and soil improvers made from recovered materials'. This sentiment was further echoed by the expert from the Dutch Ministry of Agriculture, who commented that this is a problem that is difficult to resolve.[72] They explained that standards for circular actors using treated waste streams should not be lowered, but that standards for traditional actors need to be heightened – considering that their production methods and products can also come with unwanted harms.[73]

They went on to explain that 'some of the mineral fertilisers also bring risks into the system, such as being very dependent on Russian gas or bringing cadmium from mines in phosphate fertilisers'.[74] Phosphate rock comes from mines, especially in North Africa and Morocco. When it comes from countries in Southwestern Africa, the interviewee explained that it comes with 'greater cadmium contamination, which is pretty poisonous. While the European Commission has proposed stricter rules on cadmium content, the Member States have only agreed to more lax restrictions. This would probably not be the case if we were talking about rules for resources recovered from waste'.[75] The interviewee ended on the explanation of what they perceive to be the Dutch stance on this matter, that 'we should have more balanced regulation for all types treatment and production methods of fertiliser and make more use of the renewable resources – those that already lie here within our borders, within the Union. So, we become less dependent on imports'.[76]

7.4.3 Quality Control – Other Products

One interviewee in each of our categories (EU, Dutch, Croatian) mentioned the absence of 'quality control for bio-based plastics' or other products that can come from VFG and sludge treatment. This matter was also identified in the doctrinal research, which found that there is no equivalent of the FPR for other product streams that can come from VFG and sludge, such as platform chemicals. The three interviewees who mentioned this found it to be a 'missed opportunity' because more regulatory attention relating to applications of these materials (outside agricultural land used for food) could undo the deadlock these organic resources are caught in.[77] By 'deadlock', the expert from the Dutch STOWA was referring to the fact that it is difficult for these materials to be treated to a high enough quality standard to be applicable on land where food is grown, while at the same time it is an EU objective to significantly reduce the landfilling and waste of these materials. As such, encouraging different product

[72] Ibid.

[73] Interview with the Dutch Ministry of Agriculture, (The Netherlands, 9 September 2022).

[74] Ibid.

[75] Ibid.

[76] Ibid.

[77] Interview with Dutch national knowledge centre for water boards, STOWA (The Netherlands, 30 August 2022); Interview with member of the European Compost Network (Digital, 9 March 2023).

applications by legislative means (such as providing legal certainty in the form of quality control standards) would release this 'deadlock'.[78]

The blind spots, tools that were not mentioned or mentioned infrequently, once again align well with the gaps identified in the doctrinal traffic light research results. The three tools that were not mentioned in any interviews were 'specific (separate) targets for reuse', and 'CE marking'. Since there were no calls for change to the 'CE marking' among interviewees it is possible that this is simply an area of the legislative system that is working as it should be and achieving the ends it should be. However, when it comes to 'specific (separate) targets for re-use', it is possible that this is a neglected part of the solution. As argued in the VFG Chapter (Section 5.4) re-use targets are not one and the same as the 'recycling and preparation for re-use' targets in the WFD's Article 11. 'Preparation for re-use' (as stated currently in the WFD) is not re-use in that it does not explicitly require re-use that is resource efficient and in compliance with the waste hierarchy. Separate re-use targets in the WFD (not jumbled in with recycling targets) would more directly impact the CE objectives and would also give more weight to the existing collection targets.[79]

7.4.4 Creation Of Markets for Recovered Material Streams

Beyond the results of the deductive coding, the open coding found some factors that could also contribute to the improvement of treatment. For the 'products' stage of the life cycle, many interviewees brought up the need to create markets for material products recovered from the two waste streams (seven in the Netherlands and five in Croatia). In the interviews, four ways in which these markets could be created were identified.

Inspiring Investment

Two Dutch and two Croatian interviewees linked the matter of market creation to the need to inspire investment among private parties. The interviewee of a Dutch secondary raw material producer explained that 'to scale up with many of these installations, we need a higher level of technological readiness. But no parties are stepping up to do that because the mark is quite conservative'.[80] This is also the reason why some of the innovative treatment and recovery methods discussed in Chapter 2 of the present research are not being applied at a major commercial scale. The same interviewee said 'these technologies need to be proven on a larger scale, but the private actors don't want to venture into it alone'.[81] When uncertainty is high but strides towards a desired objectives can be great, national authorities can intervene with measures like manda-

78 Interview with member of the European Compost Network (Digital, 9 March 2023); Interview with a Croatian bio-plastic producer (Croatia, 29 November 2022).

79 See section 5.1. 'Collection' and section 5.4 'Analysis' of the VFG chapter (Chapter 5).

80 Interview with Dutch secondary raw materials producer (The Netherlands, 30 August 2022).

81 Interview with Dutch secondary raw materials producer (The Netherlands, 30 August 2022).

tory requirements as well as soft measures like green public procurement and facilitation of information exchange. All of these are discussed in the present chapter.

A positive example of how private actors can be inspired to invest came from the interview with a representative of one of the private parties involved in the production of *Kaumera*, a raw material that can be obtained from both residual waste and wastewater and is used to create a binding material.[82] The interviewee explained how they bring traditional actors into contact with more novel circular actors and technologies to stimulate circularity of relevant materials. For example, since they are working with Kaumera Gum, the work with both the producers who are 'frontrunners of the circularity transition', but their buyers 'are much more traditional companies'.[83] The interviewee explained that it helps to look at Kaumera 'not as a product itself, but as an ingredient in a product. A private actor like Koppert Biological Systems buys Kaumera because they are already producing biostimulants. One of the ingredients in their existing biostimulants is seaweed. Harvesting seaweed comes with many concerns for the environment (scraping the seafloor, general questions of sustainability)... so Koppert is looking to replace the algae with Kaumera. They are a 'traditional company', if you prefer, an incumbent looking to replace part of their products with these novel ingredients. And there are many companies like this. I believe the same type of transition is happening in ingredients for fertilisers too – converting to biological fertilisers.[84]

When discussing where the incentive for this transition to more circular ingredients in products comes from, the interviewee explained, 'It's most often not internal. There are two drivers: the first is legislation; companies know that bans on products that cause environmental harm are coming, such as diesel cars. So, companies are trying to get ahead of these bans. The EU and national governments could do more to make it clear that there will be a ban or at least limits placed on the use of non-sustainable substances in products like fertilisers or other relevant materials. And the second is consumers, if the clients refrain from buying products with unfavourable materials like algae...then, you have to submit.'[85]

Mandatory Composition Requirements

In the interview with a Dutch secondary raw materials producer, the idea of using mandatory composition requirements to accelerate the transition first came up. The interviewee used the Dutch word 'bijmengverplichting', stating that they find this to be an important incentive for increasing treatment for

[82] See section 2.5 of Chapter 2 on the General and Biotechnological State of the Art for VFG and Sludge Waste Streams.

[83] Interview with Dutch engineering consultancy firm (The Netherlands, 27 September 2022).

[84] Ibid.

[85] Interview with Dutch engineering consultancy firm (The Netherlands, 27 September 2022).

recovery and market creation for VFG and sludge products.[86] They said 'once the TRL is up and you have the volume and quality of input materials required, then we need mandatory composition requirements. Requirements that oblige actors to use a certain percentage of recovered materials in a product. If you are able to implement that, then you create a market pool and things will begin to run more easily. The price will go up and everyone will start running to make the product'.[87]

After this, when explicitly asked about it, six other interviewees across institutional levels agreed that the addition of mandatory requirements would be an important incentive for improving both the uptake of novel treatment methods for VFG and sludge, as well as market creation for products containing a percentage of organic materials recovered therein.[88] This confirms the finding from one of the preliminary interviews performed at the very beginning of this research with a representative at Attero, a Dutch waste treatment company. The representative explained that the only way we will achieve recycling of materials like phosphate and other organic matter is if companies are 'forced' to use them in their products.[89] Otherwise, the market incentives to do it are simply not present.

Such mandatory obligations can be applied in the 'treatment' or 'product creation' stages of the material life cycle. For example, Germany is the first country to apply such regulatory pressure, and it has chosen to do so in the 'treatment' stage by making phosphorus recovery from sewage sludge obligatory in its 2018 revised sewage sludge Ordinance.[90] The Ordinance made the process obligatory for all larger German wastewater treatment plants, which now have to recover phosphorus if the sludge contains more than 2% phosphorus dry solids; otherwise, they have to incinerate the sludge in mono-incinerators.[91] Land application of sludge will only be allowed for smaller wastewater treatment plants. The largest wastewater treatment plants account for approximately 66% of the total phosphorus removed from German wastewater and transferred to the sludge. These new requirements will have to be fulfilled by 2029, with a twelve-year transition period.[92]

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86 Ibid.

87 Ibid.

88 Interview with Dutch national knowledge centre for water boards, STOWA (The Netherlands, 30 August 2022); Interview with member of the European Compost Network (Digital, 9 March 2023); Interview with Dutch Directorate General for Public Works and Water Management, Rijkswaterstaat (The Netherlands, 31 August 2022); Interview with member of the EU Environmental DG 'from waste to resources' (Digital, 7 March 2023); Interview with a Croatian bio-plastic producer (Croatia, 29 November 2022); Interview with a Dutch bio-plastic producer (The Netherlands, 17 November 2022).

89 Interview at Attero Waste Treatment Plant (The Netherlands, 20 November 2019).

90 European Sustainable Phosphorus Platform, 'New sewage sludge ordinance passed the German cabinet' (Phosphorus Platform, 2020).

91 European Sustainable Phosphorus Platform (2020).

92 Ibid.

Previously, Germany had mainly spread sewage sludge on arable land, but this practice will be greatly reduced as a result of this Ordinance, which is why it is also part of Germany's implementation of the EU's nitrates directive. This Ordinance seems to be a good example of prioritised objectives because the spreading of sewage sludge on arable land is reduced (safety objective), while valuable resources are also prioritised and conserved (circularity and environmental objectives). This is certainly a more balanced approach to the various objectives at play, rather than simply putting in place a ban on use in agriculture without creating any other optimal solutions for what to do with waste streams other than landfill or incinerate without recovery.

Trade of Recovered Materials

One of the barriers relevant to market creation is that both the Netherlands and Croatia have only a small national market for valuable organic products that could be recovered from VFG and sludge. In the Netherlands, this market is already saturated with manure and other fertiliser product ingredients.[93] In Croatia, the national market is not big enough to justify investment into the installations needed for treatment and recovery.[94] When discussing solutions to this in the empirical interviews, it was frequently mentioned the recovered materials could be transported and traded with other countries where the markets have a greater need for these products in their agricultural and other sectors.

There are environmental cost/benefit issues with this solution, but even if these were overcome, the trade of end-of-waste materials can be a complicated legal matter. When a substance is classified as waste, the European Waste Shipment Regulation (EWSR) for cross-border transport applies.[95] The Regulation distinguishes between two procedures: the green list procedure and the orange list procedure.[96] The green list requires no authorisation from authorities if the substance is going to certain countries and if the substance has a useful application. In that case, the information obligation will suffice. A legally binding contract between the client and the purchaser is required, which also includes an interim storage and take-back obligation. In addition, a completed and signed information form (Annex VII of the EWSR) must be present during transport.[97] The orange list contains substances for which a notification procedure applies. This means that for transport in accordance with the EWSR, permission must first be requested from the transport authorities in the countries concerned.

When the substance has an end-of-waste status, there are different procedures for transferring the substance, based on whether it has EU or national

93 Interview with the Dutch Ministry of Agriculture, (The Netherlands, 9 September 2022).

94 Interview with a Croatian bio-plastic producer (Croatia, 29 November 2022).

95 Van den Dungen & van Schöll (2022) 5.

96 Rijkswaterstaat, 'Afvaltransport over de grens (EVOA)'.

97 van den Dungen & van Schöll (March 2022), 5.

end-of-waste status.[98] A European end-of-waste status is valid in all EU Member States and the substance is therefore recognised as a product everywhere, but EU-wide status does not yet exist for many products – such as incineration ashes, for example. In this case, the EWSR does not apply because the matter no longer concerns waste. For a national end-of-waste status, the EWSR continues to apply if the recipient country regards the substance as waste. If the recipient country recognises the substance as a product, the conditions of the EWSR no longer have to be met. This means that transport without the EWSR procedure is possible if both the sending country and the recipient country do not classify the substance as waste.[99]

Green Public Procurement

The final tool relevant to market creation is the absence of top-down green public procurement as an inventive means of recovery and reuse. The problems that arise from its absence are revealed by looking at the example of Den Haag. As explained in Chapter 5 on VFG, Den Haag is one of the municipalities that faces challenges when it comes to separate collection (particularly of VFG) because it is densely populated with many high-rise buildings (which are known to cause collection issues in separate collection systems). To address these challenges, the municipality implements many of the common policy measures used to improve collection (access to information for citizens, door-to-door collection, conveniently located waste drop-off points, etc).

Although policy documents and EU legislation place an emphasis on source-separated waste, this is becoming less of a practice across Dutch municipalities – including Den Haag. Since citizens were not effectively separating their waste into streams, many municipalities (Amsterdam, Utrecht, Den Haag) have started to move away from source separation and have begun sending their waste to be separated by machines at the facilities of various processing businesses.[100] Many municipalities are now moving to this method in the hopes of ensuring higher quality collected waste, leading to better opportunities for recovery and higher quality recovered material streams.

When it comes to the treatment of VFG waste, it is mainly the regional and national authorities that have the competence, meaning that municipalities like Den Haag have less influence on this part of the life cycle. This makes sense considering that the waste treated in these installations does not come from a single municipality. However, an area relevant to the valuable raw materials contained within the VFG where a municipality does have some influence is resource conservation. Municipalities in the Netherlands draw up resource management plans, with which they influence how the resources belonging to the city will be used. This includes the valuable raw organic materials contained

98 Ibid.

99 Ibid.

100 Den Haag Council, Grondstoffenplan Den Haag 2021.

within waste streams like VFG.[101] Den Haag is quite progressive in this area, having committed to keeping valuable resources within the city as much as possible so that they can be reprocessed into new products by local entrepreneurs.[102] In this way, cities attempt to control how resources are used in the hopes of closing feedback loops and creating circularity.

However, the extent to which this is effective in practise has been raised in the empirical interviews conducted in this investigation. An interview with an expert from the municipal authorities in Den Haag explained that the current collection and treatment practices lead to much of the power over these resources ending up with the waste processing companies at the very end of this material life cycle.[103] Since it seems that some Dutch municipalities are slowly moving away from source-separated collection, waste processing companies are having to do the bulk of waste separation. Through this, the competence, the power to act, is handed over to private actors who may not share the same circularity objectives as the institutional actors that precede them in the life cycle.

Once waste processing companies become holders of the waste, it is up to them how the materials are treated and where the treated materials streams end up. Although this could simply be solved through legal obligations, the development of these obligations is often slow, especially in parts of the sector where such novel treatment methods are being applied. There is significant pushback to such obligations in new, innovative markets, such as those of materials recovered from VFG.[104] This is a power gap in the life cycle of materials. Although Dutch municipalities are tasked with drafting and implementing resource management plans and waste plans, they have little control over the resources that are created from their city's waste (under the current system). The municipal authorities in Den Haag have proposed a solution to this loss over resource control, via green public procurement contracts.[105] This would entail maintaining some degree of control over the recovered materials by including clauses in contracts with processing businesses that require them to, for example, cycle a certain percentage of the recovered materials back into the city from which the waste originated.[106] As such, cities would have greater control over the feedback loops at the end of the material life cycle, abide by circularity objectives and cycle the valuable materials back into municipal entrepreneurial ventures.

The literature on this topic indicates that there are opportunities to include green and circular objectives in the public procurement process, but there are considerations that have to be made before delving into this as a solution,

[101] Den Haag Council (2021) 4.

[102] Ibid.

[103] Interview with the municipality in Den Haag (The Netherlands, 11 May 2022).

[104] Ibid.

[105] Ibid.

[106] Interview with a Croatian bio-plastic producer (Croatia, 29 November 2022).

including a weighing of competing objectives.[107] The requirements calling for materials to be treated in a specific way or for certain percentages to be returned to the city can be included either as contractual conditions or as an award criterion in an open tender. In both cases, adding such a clause can be beneficial because it becomes a requirement that must be fulfilled. Be it a contractual condition or an award criterion in a tender, from a public procurement perspective its essential that the minimum competitive procedural requirements are met (equality, transparency, non-discrimination and proportionality).[108]

In the case of an award criterion, there is the added benefit of businesses competing for the contract. Interviews with experts at both the EU, national and local level have indicated that this can increase the possible results (for example, because companies will push themselves to demonstrate that they can treat larger quantities of waste and provide higher quality material streams),[109] as well as increasing the likelihood that companies will work together, combine know-how and apply collaboratively to a tender (to increase their chance of getting the contract).[110]

When it comes to competing objectives, an array of issues can arise. For example, if the principle of non-discrimination is followed in a tendering process, the call must be open to companies across the whole of the EU (not just Dutch companies, or companies in the vicinity of Den Haag). Although this would meet the EU free market objective of non-discrimination, it would run counter to the circular economy and waste management objectives of treating and processing waste as close as possible to the source. This would further add to the complicated objectives-balancing that takes place in the process of transitioning to a circular economy and lead to potentially fragmented solutions across different municipalities and Member States.

The example of Den Haag demonstrates a bottom-up drive for change on this matter. It shows that this is an area where local governments and businesses have begun to need solutions and possibly an area where more local

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107 S.D. Sönnichsen & J. Clement, 'Review of green and sustainable public procurement: Towards circular public procurement', Journal of cleaner production, 2020 (245) 2.

108 A. Sundstrand, 'The transparency requirement based on legal principles-the possibilities of exceptions from the requirements of transparency when awarding public contracts covered only by EU primary law' In 5th International Public Procurement Conference, 2012, Washington DC, USA, 175; S. Kirchner, 'More Fairness in Global Procurement: The European Union's Future International Procurement Instrument Moves Closer to Reality, SSRN Electronic Journal 2021', 4; Commission Internal Markets and Services DG, 'Buying social: a guide to taking account of social considerations in public procurement' (European Commission DG, October 2010), p. 31.

109 Interview with a Croatian bio-plastic producer (Croatia, 29 November 2022); Interview with the Dutch Ministry of Infrastructure and Water Management (The Netherlands, 23 January 2022).

110 Thank you to Mr. dr. Willem Janssen, Associate Professor in European and Dutch Public Procurement Law at the law department of Utrecht University, for his help in wading through this massive topic to get to the core of what is relevant for the present research.

governments will be reaching out for solutions in the future (as recycling targets and targets to minimise landfilling continue to increase at the EU and national levels). In the absence of a top-down, unified approach to resource management at the end of this material cycle, a fragmented landscape of solutions at the municipal level will continue to develop.

CHAPTER 8

Discussion and Conclusion

According to the latest circularity gap report from 2023, we live in the overshoot era, and each year our economies are *less* circular rather than *more* circular. For example, the 2023 report finds the global economy to be 7.2% circular, while in 2021 the global economy was 8.6% circular.[1] This is despite continued research on the circular economy, advancements of relevant technologies and growing attention to the circular economy transition. This indicates that overall, we are not on track to meet circular economy and resource circularity objectives.

To grasp the shortcomings of current frameworks in achieving EU-wide circularity objectives and to develop incentives that could counter the shortcomings, the present chapter intends to bring together the main findings from the previous chapters to see how the desired circularity for VFG and sludge materials can be improved. The research has first delved into understanding the current state of affairs and the general function of the law in the circular transition for VFG and sludge waste management (8.1 – 8.4). It has then outlined several recommendations relating to removing legislative barriers (8.5) and creating legislative incentives (8.6) to steer management of organic resources towards the relevant circularity objectives.

8.1 General Findings

When looking at the general legislative landscape in the transition towards circular material use for VFG and sludge waste, it was identified early on in the research that legislation could either be a hindrance or an incentivizing factor. The doctrinal part of the present research has shown where there are gaps in the legislative and policy tools available over the course of VFG and sludge materials' lifecycle.[2] The empirical research has shown where these gaps turn into barriers to the achievement of environmental conservation and circularity, as well as how possible incentives could be put in place. By 'barriers', this research refers to legal and policy obstacles at EU and national levels which are hindrances to the application of circular biotechnological methods in waste recovery.[3] By 'incentives', this research refers to types of EU or national legislation that could motivate those public and private actors to go above and beyond the minimum legislative requirements.

For a concrete example of how legislation can be a hindrance and pose barriers to circularity, we can look to the outdated VFG collection targets at the EU level, which both the doctrinal and empirical research have found to be too focused on quantity and weighed targets, with not enough attention paid to quality targets for reuse.[4] This is a barrier, and not a lack of incentive, because

1 Circle Economy, 'Circularity Gap Report 2021' 9. Circle Economy, 'Circularity Gap Report 2023' 10.

2 See section 5.4 of the VFG Chapter (Chapter 5), and section 6.4 of the Sludge Chapter (Chapter 6).

3 Backes (2017), 2017.; de Waal, (2023): 935.

4 Interview with member of the EU Environmental DG 'from waste to resources' (Digital, 7th March 2023).

modernized, relevant targets would be an incentive. While existing, outdated targets that no longer apply well to the situation in the sector are a barrier. The call here was for more research and legislative attention as to how best to define quality targets to improve quality assurance for treatment operators in the later phases of the materials' lifecycle.[5] One way in which this could be done is by focusing WFD targets to 'distinguish between the various recovery processes, in such a way that resource efficient and environmentally safe recovery has to be given priority'.[6]

Defining circularity targets is a real issue and something that is urgently missing. The existing targets often concentrate on avoiding landfilling and incineration and were drafted in a 'pre-circular policy' time. They need to be updated if they are to drive forward the circularity transition. In such a way, the new targets could incentivize the transition, rather than hindering it. That brings us to the second general function of the law relevant to the present research: law as an incentive. The combined doctrinal and empirical findings also give an indication of the incentives to be applied (mainly by public actors) in overcoming the identified barriers.

An incentive does not always need to come in the form of a subsidy (though those are certainly useful). The present research has highlighted how an incentive for circularity can come from shifting legislative attention to a different part of the material lifecycle. Instead of focusing only on treatment and production, obligations around resource conservation at the very beginning of the material lifecycle (ie: reduce the mining and use of virgin raw materials) can have great impact on creating feedback loops over the course of the material lifecycle.

8.1.1 Biotechnological Treatment Methods for VFG and Sludge

Legislation's power to hinder or incentivize this transition is affected by the biotechnological research which is simultaneously taking place. Chapter 2 of the present research dealt with the various biotechnological methods that could be applied to recover material streams and make products from VFG and sludge waste. The aim of describing the full life cycle of the materials that end up in the VFG and sludge streams was to illustrate the way the different stages of the two lifecycles are interconnected and feed into each

5 In this case quality targets refer to the quality of the input material and of the resulting end product of re-processing. As explained in Chapter 5, quality and re-use targets 'would more directly impact the CE objectives and would also give more weight to the existing collection targets. When experiencing the cycle holistically one component drives the other: Member States are more incentivized to reach the collection targets, and re-process their waste maximally in-line with the waste hierarchy if they are also pushing to achieve re-use targets', See section 5.4 of the VFG Chapter (Chapter 5). Interview with member of the EU Environmental DG 'from waste to resources' (Digital, 7th March 2023); Interview with the waste service provider in Den Haag (Netherlands, 11th May 2022).

6 Arm et. al (2017) 1491.

other.[7] The most important examples of this interconnectedness was the connection between the raw materials contained in both VFG and sludge (N, P, K) and agricultural production. The chapter highlighted that the goals of minimal external inputs and closing nutrient loops are closely related. Nutrient loops can be closed by recycling nutrients from the waste streams and using them in agricultural production (as fertilizers and other types of soil amendments), which at the same time, reduce the amount of external inputs to the agricultural process – in the form of chemical fertilizers that are dependent on non-renewable raw materials from the Earth.[8]

The chapter also explained the different challenges surrounding VFG and sludge collection and identified a number of treatment options, with a focus on those that enable the recovery of high value materials that can be circled back into the economy. The chapter covered relevant biological, physico-chemical and thermo-chemical treatments. Though a legal research is not well placed to provide the final word on the most suitable treatment methods for the circularity of VFG and sludge materials, the chapter does discuss the advantages and drawbacks of both novel and commonly used treatment methods. From these, anaerobic digestion and composting (biological treatments) are identified as the most widely applied treatment methods for both streams and a good basis for the necessary material recovery in the short-term. The most important drawback of the other biological treatments, black-soldier fly treatment and vermicomposting, is that they inevitably trigger a host of legal issues related to animal by-products and feeding of waste to insects – which further complicate an already complex end-of-waste environment at the end of the material feedback loop.[9] Through communication documents the European Commission has demonstrated an awareness of the need to provide latitude in this area (to facilitate use of alternative reprocessing methods), but before taking concrete legislative steps in this direction there is still research being done by regulatory bodies on biosafety, hazardous contaminants and allergens.[10]

7 See the introduction to the chapter on the General and Biotechnological State of the Art for VFG and Sludge Waste Streams (Chapter 2).

8 Ibid.

9 See 'Opening a Literal Can of Worms' in section 5.2.2 of the VFG Chapter (Chapter 3): 'The product of vermicomposting is legally classified as animal manure and because worms simply do not consumer all types of waste. Products made from processing animal manure, such as the compost resulting from vermicomposting, have to meet regulatory requirements for animal by-products. […] The EU has legal restrictions when it comes to feeding waste to insects. Annex III of another 2009 regulation, on the placing on the market and use of feed, prohibits the use of faeces and separated digestive tract content for insect production. In addition to this the ABPs regulation considers insects as 'farmed animals' and thus does not allow manure, catering waste or former foodstuff that may contain meat and fish as feed.'

10 Lohri (2017) 95; EFSA Scientific Committee (2015) Risk profile related to production and consumption of insects as food and feed. EFSA J 13(10):4257.

Other, more bio-technological, studies on this topic confirmed that anaerobic digestion and composting 'provide a solid basis of bio-waste management, to which novel technologies can be coupled', such as processes in which waste serves as a source of bio-based chemicals, fibres and nutrients.[11] A benefit of treatment facilities in the short-term focusing on anaerobic digestion and composting is that these are technologies of a high readiness level and treatment plants are familiar with how to operate them to connecting technologies that could deal with the contaminants, thereby meeting the necessary legislative requirements (such as limits on concentration on heavy metals and organic pollutants). This reduces the likelihood of any potential barriers in the feedback loops from treatment back into production through end-of-waste.

8.1.2 The Legislative Landscape

While the science around treatment options and creation of products from recovered material streams continues to develop, it might seem like the best option for there to remain as little legislation as possible relating to these topics. Seeing as the techniques around collection, treatment and production for VFG and sludge materials are still evolving with new ideas continually being developed, there are benefits to legislation remaining minimal to allow for the necessary innovation that is taking place.[12] On the other hand, both the empirical interviews and one case before the CJEU have demonstrated how an absence of clarity in this area can lead to uncertainty among relevant actors and mistakes being made in the set-up of circular treatment systems.[13] The interviews demonstrated that some private actors and municipalities are hesitant to act in the an absence of guiding rules in existing legislation (as is the case with market entry for bio-plastic products made from recycled waste).[14] Meanwhile, the Sappi waste and paper pulp treatment case before the CJEU has demonstrated how a lack of legislative clarity can lead to expensive mistakes on the part of WWTPs in terms of how they set up their processes.[15]

Further to this, a relevant matter is not only the quantity of legislation on this topic (too little or too few rules), but also the type of legislation. More legislation might be beneficial to improving legal clarity (for example through better defining key terms, concepts and targets). Examples of this which came up in

[11] European Compost Network, 'Bio-Waste Management plays a Keyrole in Bioeconomy' (2020).

[12] See discussions of novel treatment methods in section 2.4 of Chapter 2 and various discussions on best practice for collection of waste streams in section 5.1 of the VFG chapter.

[13] 'Mistakes' here refers to treatment practices being put in place that actors intended to be legal, but that ended up being illegal due a difference in the way rules were interpreted; Backes & Kajić (2022) 248-258.

[14] See section 7.3 of the Results chapter (Chapter 7).

[15] Case C-629/19, Sappi Austria Produktions-GmbH & Co. kg and Wasserverband 'Region Gratkorn-Gratwein' v Landeshauptmann von Steiermark [2019] ecli:EU:C:2020:824; Backes & Kajić (2022) 248-258; See section 6.4.1 'EU Level' of the Sludge chapter (Chapter 6).

the present research are for example more clarity on how to carry out 'sustainability balancing' in practice. As touched upon in the VFG chapter this is a concept that has been present in the law for a long time, especially through the Industrial Emissions Directive, yet it is not sophistically developed in practice.[16] Other examples are the collection targets for the VFG waste stream (discussed above), the definition of waste under EU law and the definition of end-of-waste criteria for more waste streams (either at the EU or national level). In contrast to this, legal rules requiring certain treatment techniques or over-defining input materials and end-characteristics could hinder innovation. These are the types of rules from which legislators should refrain. This is yet another precise balancing act which should be taking place in the legislative landscape alongside the balancing of competences in the multi-level institutional organization relevant to the transition; and the substantive balancing act between the different (sometimes clashing) objectives relevant to VFG and sludge materials.

8.1.3 Multi-Level Organization

To ensure that organic resources from VFG and sludge waste are treated in a circular manner, in-line with the over-arching circularity objectives outlined at the EU level, attention needs to be paid to institutional power flows and competence. The proportionality and subsidiarity assessment in Chapter 3 illustrated that Union action is possibly relevant to this topic and could increase efficiency in reaching the relevant circularity objectives. However, it also illustrated that this is not necessarily a preferred route because of the resistance Member States have shown to further Union action on such a locally specific issue.

The balance of power relevant to topics discussed in this research is shifting, as we learn that creating a closed loop circular system for many of these resources requires more of a product law, rather than a waste law perspective. This is evident in the proposal of an Eco-design regulation (relevant for both fertilizers and bio-plastics), taking over the Eco-design directive – inherently giving more direct, specific applicability to EU law in Member States. The legal basis for this regulation is Article 114 TFEU and the internal market justification is convincing in that it demonstrates how this broad internal market legal basis can be a platform 'for the balancing and achievement of economic, but especially also of a broad range of non-economic public interests' (such as the circular management of products and resources).[17]

As discussed in Chapter 3, this tension generated by the principles of subsidiarity and conferral of powers is also present in the 'treatment' part of

[16] See section 5.2.2 'Industrial Emissions Directive' of the VFG Chapter (Chapter 5); Bohne, Eberhard. The quest for environmental regulatory integration in the European Union: integrated pollution prevention and control, environmental impact assessment and major accident prevention. Vol. 10. Kluwer Law International BV, 2006, p 27.

[17] Van den Brink & Passalacqua (2023) 3-4.

the lifecycle, where the most relevant legislative area is also waste management with a legal basis in Article 191 and 192 of the TFEU. What is interesting in this part of the lifecycle is that the 2008 version of the Waste Framework Directive (herein: WFD) stated in perambulatory clause 9 that 'an emphasis on the environmental objectives laid down in Article 174 of the Treaty would bring the environmental impacts of waste generation and waste management more sharply into focus throughout the life-cycle of resources.'[18] No such clause exists in the 2018 updated version of the Directive, in which Article 38a instead lays out the legal bases as they relate to specific articles (ie: specific waste streams). Article 11(a) touches upon bio-waste (including VFG) for which the power to adopt delegated acts is conferred to the Commission for a period of five years from 4 July 2018. Seeing as this period ends at the time of writing in 2023, it will be interesting to see how the competence balance shifts in the coming period and what affect it will have on the management of VFG waste. Meanwhile, management of sludge (while it is still a part of wastewater) is governed by the Urban Wastewater Treatment Directive, which finds its legal basis in TFEU Article 192(1).[19]

For both waste streams in the 'treatment' part of the lifecycle the most relevant question is actually who has the power to decide which type of waste installation should be used (landfill, composting plant, recycling plant, incineration plant). Currently, this choice is completely at the discretion of Member States. While Article 4 of the 2018 consolidated WFD does define the waste hierarchy, legally speaking this is only a 'recommendation' in that Member States are only required to '*encourage* the options that deliver the best overall environmental outcome'.[20]

When competence is placed with Member States we see many examples of fragmented implementation and hesitancy to act (as seen in the example of end-of-waste criteria, conformity assessments bodies, collection methods, reporting, etc.). Further to this, when competence is placed with local authorities we have seen how the power to act can slip away from public actors all together – as in the example of resource management and green public procurement in Den Haag. All these examples hamper the transition to a circular agri-food system and demonstrate how elusive institutional power can be.

As such, this barrier to circularity requires a careful balancing of competence. On the one hand, it is not desirable for a fragmented landscape to continue developing at the municipal or national level – with diverse action (and varied success) on central, Union-wide objectives. On the other hand, Member States have shown resistance to an over-extension of Union competences in this area, particularly in relation to waste law.[21]

18 Waste Framework Directive [2018] preambulatory clause 9.

19 European Parliament (March 2023).

20 Krämer (2012) 335 (10-11).

21 See section 3.2.1 of Chapter 3 on the Legal Basis for EU Action Relevant to the VFG and Sludge Material Streams.

This leaves us with the member state, national level. We have seen how some Member States (like the Netherlands) do go beyond EU law to meet environmental and circularity objectives. An example of this are the Dutch minimum treatment standards in the LAP3, which to some extent turn waste hierarchy recommendations into requirements. This could continue for VFG, as from the perspective of institutional power it seems that national authorities are best placed to provide guiding standards in this area by harmonizing some of the fragmented solutions currently on the table. For example, through the adoption of public procurement legislation or the strengthening of legal requirements for public actors in this sector.

At the EU level, this type of national drive to meet the circularity objectives could be supported and further facilitated through concrete legislative means (section 8.2.5 & 8.2.6), but also through softer guiding measures (section 8.2.4.). In this way the EU can help Member States comply with existing substantive targets and circularity objectives, not just setting new ones.[22]

8.1.4 Clashing Objectives

The research has identified some clashes in the different public interest objectives that are offered a high level of protection at the EU level such as human, animal and plant health, safety and the environment. The 'clashing' of these objectives, refers to the fact that Member States often seem uncertain about how to weigh these different objectives in a legislative context when it comes to circularity matters such as the ones at hand.

For example, when discussing the application of new materials in agriculture (such as treated VFG and sludge products) it can be difficult to weigh the environmental objective (circularity, reuse of resources, limiting the mining of virgin resources) against the safety objectives, such as human, animal and plant health. It raises many questions about how much caution is needed when introducing these materials into products. An example here are the different standards applied to traditional and circular fertilizer products. As explained in the empirical chapter by the expert from the Dutch Ministry of Agriculture, who commented that 'standards for circular actors using treated waste streams should not be lowered, but that standards for traditional actors need to be heightened – considering that their production methods and products can also come with unwanted harms'.[23]

In addition to public interest objectives, some clashes with other EU objectives have also been uncovered – such as clashes with the single market objectives. An example of this is the green public procurement issue brought

[22] We have seen that the EU already does this in some cases, See section 3.2.1 of Chapter 3 on the Legal Basis for EU Action Relevant to the VFG and Sludge Material Streams; Section 6.4 of the VFG Chapter (Chapter 5).

[23] Interview with the Dutch Ministry of Agriculture, (Netherlands, 9th September 2022).

up at the municipal level.[24] If the EU principle of non-discrimination is followed in a green public procurement tendering process the call must be open to companies across the whole of the EU (not just Dutch companies, or companies in the vicinity of the municipality). Although this would meet the EU free market objective of non-discrimination, it runs counter to the circular economy and waste management objectives of treating and processing waste as close as possible to the source. As such, although both EU and national legislation highlight the importance of resource conservation as an objective, the organisational nature of waste treatment in practice sometimes requires local authorities to take actions that run counter to circularity and resource conservation objectives.[25]

We see from these examples how it can be difficult for national and local authorities to know where to place their emphasis and which objectives to prioritize. EU legislation could be retroactively aligned with green deal and circularity objectives through a mainstreaming clause, but most importantly, any new documents and legislation should be drafted with these considerations on the table. Further to this, the confusion at the member state level can be resolved through hard and soft guidance measures from the EU level, which are further elaborated on in sections 8.6.3 and 8.6.2.

8.2 Recommendations

The breadth of this research has meant that a variety of specific findings and recommendations (stream specific, member state-specific, institutional level specific) arose over the course of the doctrinal and empirical chapters. While all of these warranted specific attention in respective chapters, in this section we look at the few significant recommendations relevant to EU and national legislator for removing barriers and creating incentives.

Removing Legislative Barriers

In addition to the out-dated weight-based VFG collection targets mentioned earlier, there are further barriers which need to be addressed – such as those ensuing from a lack of legislative clarity and a need for balancing of legislative burdens.

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[24] See 'Green Public Procurement' under section 7.4.4. of the Empirical Research Results Chapter (Chapter 7).

[25] In this instance, and example would be local authorities choosing not to create feedback loops for VFG waste and leaving the situation in the hands of public actors, rather than going through the full EU-wide tendering process and risking the possibility of having to ship waste far away for treatment that is in line with the circularity objective. See 'Green Public Procurement' under section 7.4.4. of the Empirical Research Results Chapter (Chapter 7).

8.2.1 Legislative Clarity

The barrier of an absence of legislative clarity (or coherence) is heavily linked to the clashing objectives described above in section 8.4. The lack of clarity and incoherence is a multi-level problem. It may occur at the over-arching level of, for example, the core objectives of different pieces of legislation. However, it can also occur at the level of specific provisions. Sometimes the solution is in harmonizing that higher, over-arching level by really dealing with the core objectives of the legislation, and sometimes it is in the detailed specifics of individual provisions (that clash either with the core objectives or with each other).

To use the example of the Sewage Sludge Directive, which aims to encourage the use of sewage sludge in agriculture and to regulate its use while preventing harmful effects on soil – this research has continuously demonstrated that Member States vary in their understanding and implementation of this directive. The same Directive has led to both Spain forbidding the incineration of sewage sludge, and the Netherlands determining that all sewage sludge must be incinerated.[26] Spain is one of the six Member States that choose to allow application of *treated* sewage sludge in agriculture, putting in place strict limit values for heavy metals and other pollutants, largely similar to the limit values set out in Annex IB of the Sewage Sludge Directive (86/278/EEC).[27] The polar opposite implementations, while valid, demonstrate a lack of clarity around the core objective of the directive – is it intended to encouraging circularity of these materials or safety through incineration?

Behind this matter of clarity lies a deeper question about sovereignty and subsidiarity, namely whether the EU should be able to decide between circularity and safety around sludge treatment and application methods, or if Member States should have the competence to do so.[28] Considering that the 'right' decision in these matters is often dependent on a host of local conditions (population density, condition of the groundwater, physio-geographical conditions, acceptance of the local communities) it would seem that Member States are best placed. Nevertheless, the empirical component of this research has indicated that decisions around this topic are often plagued by uncertainty on the best-practices, as well as a series of economic and political hurdles, which lead to alternating decisions and lags in achievement of targets. A clearer way forward, provided at the EU level would lower some of these obstacles and provide easier access to the materials held in these waste streams.

At the same time as this safety/circularity clash takes place, the crops that grow on agricultural land in Spain (where treated sewage sludge was used in agriculture) can freely be traded within the internal market. This demonstrates

[26] Interreg, 'Legal Frameworks for Raw Materials from Sewage Sludge', 3.

[27] The other five member states are Greece, Luxembourg, Ireland, Italy, Portugal and Spain. EC, 'Disposal and recycling routes for sewage sludge' (Part 2 – Regulatory report), 15, 21, 33.

[28] See also: Section 8.3 of the present chapter.

a lack of legal certainty, and from some perspectives, an absence of some of the characteristics necessary for coherence.[29] As such, it has become apparent through the research that both legal certainty and coherence are subordinate objectives in the wider transition to the circular economy. Though they are not 'circularity objectives' their absence in parts of the legislative landscape creates an obstacle to the transition.

A further lack of clarity can also be seen in the way the Member States have understood the Fertilizer Product Regulation (herein: FPR). This example is perhaps more worrying because the FPR is a regulation, not a directive. As discussed in section 6.3.1 of Chapter 6, the FPR prevents compost and digestate from obtaining the CE marking, if they contain materials recovered from sewage sludge. The Croatian ordinance on by-products and abolition of waste status (NN, 117/14) that has been in force until now allowed the use of materials recovered from sludge in compost and digestate as long as it was not applied to land used for food production. Instead, it could be used in forests, parks, or for landscaping purposes. Croatia's newly proposed Fertilizer Products Act (P.Z.E. number 307) would eliminate this use application.[30]

The proposed act states that both those organic fertilizers that do bear the CE marking and those that do not are required to meet the same conditions for quality and type of raw material from which they are sourced. As such, 'neither compost nor digestate will qualify for use as organic fertilizers and soil improvers if they are made with materials from re-processed sewage sludge' – not even on the national marker for use in non-agricultural applications.[31] This entirely destroys any national market for these products and eliminates any national applications for them. Essentially, condemning them to continue being sent to landfills.[32] These seem to be weighted interests on the part of the Croatian government, that do not entirely align with the EU's objectives and which could be avoided if further clarity was provided and coherence across institutional levels was prioritized.

Meanwhile many of the non-agricultural products do not receive any legislative attention at all, making market entry for companies producing these products uncertain and complex. For example, there is no equivalent of the FPR for other product streams that are being recovered from sludge, such as platform chemicals.

A final example of a lack of clarity are the end-of-waste criteria in Article 6 of the Waste Framework Directive. We can see that there is a lot of hesitancy (both among private actors and public authorities at the member state level) in

[29] de Waal (2021) 760-783.

[30] Petrović (2023).

[31] Ibid.

[32] Croatia has no incineration or bio-gas facilities of its own. Sometimes these fractions can be shipped to treatment facilities in Italy or Australia, but this is expensive which is why landfilling is frequently the most common solution.

approaching end-of-waste and that the measure does little to improve circularity of materials that are not already being recovered and re-processed.[33]

Many of the agricultural products made from recovered materials (from sludge particularly, but also some from VFG) are classified as ‘Component Material Categories’ (herein: CMCs) in the FPR.[34] These products do not automatically receive European end-of-waste status, meaning that national legislation continues to apply to all permitted components until they have been processed into an EU fertilizing product with a CE marking.[35] In Croatia, no record was found of notification bodies that carry out independent conformity assessments with these EU requirements to facilitate market entry.[36]

In the Netherlands, the notification bodies are listed on the NVWA website. Dutch bodies for struvite and biochar exist, but at the moment there is no Dutch body that carries out the certification of EU fertilization products for CMC 13, relevant to Ashes.[37] The European Sustainable Phosphorus Platform is concerned ‘that the lack of [conformity assessment bodies] will prevent products covered by the FPR from accessing the Single Market, which will be detrimental to industries and farmers alike’.[38] These conformity assessments bodies should provide some of the necessary clarity and coherence in application of end-of-waste criteria.

Some of the interviewees in both Member States called for further guidance from the EU level, but most just called for clarity to be provided on how the criteria should be set at the member state level. This begs the question why these criteria should be set 27 times at the national level, rather than only once at the EU level. We know that the original intention for end-of-waste was that these criteria would be developed at the EU level for each waste stream, but at the moment only three exist: iron scrap, copper scrap and glass cullet.[39]

The EU Joint Research Centre has developed criteria for several other waste types (including compost), but these have not been included in the WFD because of a lack of agreement on the criteria from Member States.[40] Different Member States put varying levels of emphasis on the issue of end-of waste, partly because of the varying accessibility of virgin materials, and partly because

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33 Two EU, seven Dutch, and nine Croatian interviewees called for more clarity in the current End-of-Waste criteria frameworks, either at the EU or national level. See section 7.4.1. of the Empirical Research Results Chapter (Chapter 7) and section 5.3 of Chapter 5 on VFG; Johansson & Forsgren (2020) 1.

34 Regulation of the of the European Parliament and of the Council (EU) 2019/1009 laying down rules on the making available on the market of EU fertilising products [2019] OJ L170/1, Annex II.

35 Van den Dungen & van Schöll (2022) 8-9.

36 Fertilizer Product Regulation (2019), Article 24, 32 and Annex IV ‘Conformity assessment procedures’.

37 Van den Dungen & van Schöll (March 2022), 8-9.

38 J. Fitch ‘Joint Statement by FERTILIZERS EUROPE, IVA, EBIC and ECOFI: Urgent need for conformity assessment bodies for fertilising products’ (ECOFI Website, 30th July 2021).

39 Johansson & Forsgren (2020) 1.

40 Johansson & Forsgren (2020), 1.

of the differences in perception around acceptable risk level when it comes to re-introducing end-of-waste materials as products. Further expansion and implementation of end-of-waste rests with Member States, many of which have further decentralized the issue to local authorities.[41] This additionally complicates the legislative clarity around criteria and the steps actors have to take to achieve end-of-waste for their materials streams. A number of public and private actors have signed a joint letter to the Commission, calling for emphasis to be placed on the development of 'EU End-of-Waste status for the value chain Food, water & nutrients'.[42]

Interviewees from private companies, like the expert from a Dutch engineering consultancy firm, also called for further clarity on the relationship between end-of-waste and the REACH regulation.[43] While the expert from a Croatian consultancy company on bio-resources suggested the creation of a monitoring team for end-of-waste criteria developed at the member state level, with the hope that such a body would improve harmonization and reduce some of the confusion around the process.[44]

In combination, these barriers related to lack of clarity and confusion around clashing objectives create a high level of uncertainty for private actors looking to enter the relevant market. This causes hesitancy in the development and market entry of the products that would demonstrate advancement in the circularity transition.

When uncertainty is high but strides towards a desired objectives can be great, national authorities can intervene with measures like mandatory requirements as well as soft measures like green public procurement and facilitation of information exchange. All of which are discussed below in section 8.3 as possible incentives for the circular transition.

8.2.2 Imbalance of Legislative Burdens Between Traditional and Circular Actors

The third barrier is the misbalance between the administrative burdens placed on circular actors and those put on traditional actors. Though it shows up in various parts of the lifecycle it is most evident in the permitting of treatment methods and in the quality criteria for end-products (such as compost).[45] Multiple permits and long authorization processes for treatment

41 Waste Framework Directive [2018] Art. 6(3-4).

42 This letter came about as the result of the European Commission assessing opportunities for development of EU End-of-Waste rules for a number of waste streams, as announced in the Circular Economy Action Plan (CEAP). The CEAP designates ($3.7) 'Food water and nutrients' as a key product value chain, 1.

43 Interview with Dutch engineering consultancy firm (Netherlands, 27th September 2022).

44 Interview with employee at a Croatian bio-resource Consultancy (Croatia, 31st May 2022).

45 See Articles 3 and 15 of the Waste Framework Directive and empirical examples given in section 7.3 of the Results chapter (Chapter 7).

methods are in place, as well as End-of-Waste and REACH obligations for recovered material streams.

It should be clear that reorienting this balance and overcoming this barrier is not about lowering the standards for circular actors, and thereby potentially doing harm to a public interest like safety. Instead, the aim should be to raise the standards for traditional actors and re-consider the materials that we currently allow in agricultural and other product applications.[46] If we are exercising caution around circular products we should also exercise caution around traditional products, such as mineral fertilizers.

It seems that most current legislation is written for fossil fertilizer producers, while interests and needs of circular actors are not taken into account.[47] Future legislation and policy in the treatment and products parts of the lifecycle particularly need to be drafted with recycling and recovery operators and circular products in mind.

Creating Legislative Incentives

The above findings suggest that current legislative frameworks do pose barriers, and do not always actively incentivize circular waste collection, treatment and market entry of recovered products (in the VFG and sludge waste streams). The section below looks at the legislative and policy tools this research has identified as possible incentives, which public and private actors can harness to overcome barriers.

The research findings (based on both the doctrinal and empirical research), place the impetus for incentives on public actors. While there are steps that private actors can take to incentivize the transition around resources recovered from VFG and sludge waste, like providing the necessary technical know-how and meeting reporting requirements, public actors will need to be the ones taking the lead to incentivizing this transition.[48]

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[46] See example from Sludge chapter in section 6.4.2 'Member State Level': 'it is helpful to look at the level of precaution exercised around agricultural application of products recovered from sewage sludge and precaution exercised around manure. Bio-technical studies on this topic have compared pollutants in these two streams, and found that for many the difference is minor or that manure is actually more polluted. This is easiest to demonstrate with heavy metals. A 2014 study from Wageningen University found that nickel content of sludge was 1025mg per kg, while for cow manure it was 1472mg per kgP. Similarly, sewage sludge had a copper content of 12701mg per kgP, while cow manure had 14397mg. Of course, there were also heavy metals (like zinc) where sewage sludge had the higher content (sewage sludge: 31166, cow manure: 25947mg per kgP), but this example is not intended to illustrate that there are no pollutants to be removed from sludge. Rather, that many of the pollutants we are precautious about with sludge are exactly the pollutants that we already apply in agriculture via manure. This is just one example of a recurring trend in this area where the status-quo is not as stringently regulated and allowed to continue freely, while novel methods are banned or severely limited due to precaution.'

[47] Similar findings, for slightly different streams, are also reflected in research done by Hukari, Hermann, and Nättorp (2016), 1134.

[48] Both 'providing the necessary technical know-how' and 'meeting reporting requirements' were open codes born out of the empirical component of this research.

8.2.3 Attention for Resource Conservation

The combined results of the empirical interviews and the doctrinal traffic light table (small number of identified tools, small number of applied tools, small number of mentions in the empirical interviews) indicate that conservation of critical raw materials is a heavily neglected part of the material life cycle. For example, despite future scarcity of critical raw materials (such as phosphorus, potassium, magnesium, sulphur and a series of micronutrients) and their importance for the EU and global economy, there are no binding legal frameworks on Critical Raw Materials at the EU level, nor in the Dutch and Croatian national law.

This is a shame, because those interviewees who did mention the lack of attention, see the need for it as critical for the conservation of these valuable materials and for the improvement of their recovery and reuse in later stages of the lifecycle. This is backed up by the literature and EU policy in this area, which finds that critical raw materials 'are significant when considering issues of material security, since the EU relies heavily on imports of many CRM's. They are therefore of value and importance to the EU economy, to EU industrial jobs, and to sustained economic growth within the EU'.[49]

There is already movement in the right direction in this area through proposals such as that for the new eco-design regulation (which is targeted at products, but will affect conservation of resources at the beginning of the cycle by encouraging more circular practices across the supply chain). In addition to these types of proposal, this is an area in which additional binding requirements should be put in place at the EU level, proportionate to the public interest of environmental conservation. Requirements specifically limiting mining of virgin CRMs, requirements around composition of relevant products (agricultural products, but also various products that could use platform chemicals) will play an important role in conservation of these valuable resources.

8.2.4 Providing Guidance

As identified in the Chapter 7, the need for clear, coherent guidance is an important incentive for overcoming many of the identified barriers – particularly when it comes to lack of clarity and clashing objectives. The necessary guidance can come in many forms.

The lack of clarity and coherence relates to a more general fragmentation problem of EU law, particularly environmental law. In the absence of a general Environmental Law at the EU level there is a lack of a 'guiding light', a core foundation that all other legislative ordinances and policy documents could flow from. The solution could therefore lie in the enactment of such a general

49 The European Commission report on critical raw materials (European Commission, 2014b); Oakdene Hollins et. Al. (2017).

environmental law, the case for which is being made elsewhere in academic debate.[50]

However, the solution could also come through soft measures, such as topic-specific guiding opinion documents to explain how different objectives can be weighed or how specific articles can be understood and implemented. An example are topic-specific action plans, such as the Integrated Nutrient Management Action Plan, expected to be published by the Commission before the end of 2023.[51] In this way, the EU could provide the necessary clarity needed to help Member States comply with existing substantive targets and circularity objectives.[52] This applies to all parts of the VFG and sludge lifecycles – from guidance to help resolve confusion around best collection methods to facilitate recovery and circularity,[53] to helping resolve confusion around end-of-waste and safety standards for new products.[54]

Guidance can also be provided through more concrete legislative targets. For this topic specifically, adding re-use targets for VFG and sludge would incentivize Member States to improve their treatment practices, moving away from 'easy' solutions like incineration.[55] As explained in the VFG chapter, 'preparation for re-use' in the EU's WFD is not reuse, and it does not explicitly require Member States to perform reuse in a way that maintains resource efficiency and is in compliance with the waste hierarchy.[56] Separate reuse targets in the WFD (not jumbled in with recycling targets) would more directly impact the CE objectives and would also give more weight to the existing collection targets. When experiencing the cycle holistically one component drives the other: Member States are more incentivized to reach the collection targets, and re-process their waste maximally in-line with the waste hierarchy if they are also pushing to achieve reuse targets.[57]

Finally, guidance can be provided through other soft measures such as facilitating exchange of information. Though this is best executed at a regional or

50 M. Faure, 'To Codify or not to Codify EU Environmental Law: That is the Question', Chapter in Eds. 'Harmonisation in EU Environmental and Energy Law', 9-24; M.E. Hall, 'Environmental Law in the European Union: New Approach for Enforcement', Tul. Envtl. LJ 20 (2006): 277.

51 Commission (2020c) 9.

52 C. Jackson & E. Watkins, 'EU waste law: the challenge of better compliance' (Institute for European Environmental Policy, May 2021) 3.

53 See section 5.1 of the VFG Chapter (Chapter 5) and section 6.1 of the Sludge Chapter (Chapter 6).

54 See section 7.3 of the Empirical Research Results Chapter (Chapter 7).

55 See section 7.3 of the Empirical Research Results Chapter (Chapter 7) and section 5.4 of the VFG Chapter; As explained in the introduction, according to the bio-based pyramid incineration may be the 'easiest' treatment method but it is certainly not the one best aligned with environmental and circularity objectives; See section 1.4 of Chapter 1.

56 See section 5.4 of the VFG Chapter (Chapter 5).

57 Ibid.

local level, as described by one of the Dutch interviewees, the EU could encourage these types of measures in its consultations with Member States.[58]

8.2.5 Mandatory Composition Standards

A call for soft guidance from the EU level was continually called for in the empirical part of this research, almost as often as the call for binding mandatory obligations and composition requirements. Some interviewees called for these requirements to be set at the EU level (to ensure a level playing field), some at the member state level. Furthermore, different interviewees suggested implementation of these obligations at different stages of the material lifecycle – 'treatment', 'creation of products' and 'conservation of resources'.

This finding is aligned with the results of the doctrinal research results: that scattered policies and the occasional subsidy relevant to these treatment methods and circular products are not enough to drive the transition.[59] Instead, binding obligations need to be put in place, such as minimum percentages of recovered materials that products need to contain – for example in soil supplements, fertilizers, or bio-plastic products. Complementary to this, a maximum percentage of mined virgin materials permitted in a product can also be put in place. For example, 'Fertilizers traded on the EU market may not contain more than X% of virgin organic materials'. The former is an example of a composition requirement targeting the 'product' part of the lifecycle, while the latter is an example targeting the 'conservation of resources' part of the lifecycle.

In addition to composition requirements, there are other obligations which could be adopted to facilitate the transition. An example are technical minimum standards for treatment activities. As explained in the VFG chapter, Article 27 of the WFD promises that the Commission shall adopt such minimum standards to supplement the WFD, but it has not yet done so. Further to this, there is no mention of enforcement requirements for reprocessing installations performing treatment activities. This partially makes sense because the legislation is aiming to limit uncontrolled management of waste mainly as it relates to potential dumping and littering. Nevertheless, there is room here for stronger requirements on inspection and reporting for treatment facilities, especially in regard to their respect of the waste hierarchy.[60] Countries can also look to Germany as an example of a firm approach to this issue in the 'treatment' phase of the lifecycle. As discussed in Section 7.4.4 of the Results Chapter, Germany is the first country to make phosphorus recovery from incinerated sewage sludge obligatory in its 2018 revised sewage sludge ordinance.[61]

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58 See section 7.3 of the Empirical Research Results Chapter (Chapter 7).

59 See section 6.4 of the Sludge Chapter (Chapter 6).

60 See section 5.3 and 5.4 of the VFG Chapter (Chapter 5).

61 See section 7.4.4. of the Results Chapter (Chapter 7); Previously, Germany was mostly spreading sewage sludge on arable land, but this practice will be greatly reduced as a result of this ordinance, which is why it is also part of Germany's implementation of the EU's nitrates directive. This ordinance seems

These examples demonstrate that it is possible for such requirements to be set at the national level. However, clashes between the single market, circularity and public interests objectives could be minimized if they were set at an EU-wide level. Additionally, it would be useful if these requirements would apply for the entirety of a specific product market (ie: all fertilizers, or all plastic packaging made from bio-plastics). However, if this would be too big of a leap to start with, it would be beneficial to integrate such requirements into existing instruments, such as 'eco-labels' or the 'Circular Economy marking' (CE Marking). This possibility is discussed in the doctrinal findings, and backed by interviewees in the empirical findings.

8.2.6 Aligning Administrative Burdens with Circularity Objectives

The empirical research has uncovered that in some instances the existing permitting frameworks (at both the EU and national levels) are not aligned with the achievement of circularity objectives, as explained in the example of permits of 'traditional' and 'circular' actors in section 8.5.2.

This incentive includes both the balancing of standards and of permitting requirements for traditional and circular actors. Permitting, and other administrative laws, can be a strong driver of actions that are desirable for improving the circularity of raw organic resources in all parts of the cycle. For example, if permits were issued only for waste-to-energy facilities that treat non-recyclable waste, it would be an example of administrative requirements pushing markets into greater alignment with, for example, the bio-based pyramid. Chapter 1 of this research explained how incineration and energy recovery is the easiest way to convert biomass into a product, but how this is not an example of a bio-based, ecologically desirable practice.[62] If limitless numbers of these types of installations continue to receive permits, we will not be transitioning into an economy where the resources we want to value are recovered and reused. However, if permits for new waste-to-energy facilities are only granted when they intend to only treat non-recyclable waste, then the administrative requirements would be in alignment with the circularity objectives and a driving force in achieving them.

Despite this useful example, this matter is broader than permitting. Member States need to align day-to-day general waste and administrative law with the over-arching circularity objectives. The biggest examples of this that emerged

to be a good example of prioritized objectives because spreading of sewage sludge on arable land is reduced (safety objective), while valuable resources are also prioritized and conserved (circularity and environmental objectives). This is certainly a more balanced approach to the various objectives at play than simply putting in place a ban on use in agriculture without creating any other optimal solutions for what to do with the waste streams other than landfill or incinerate without recovery.

62 Centre of Biobased Economy, 'The basic principles of a biobased economy' (CBBE Website, 2018).

related to landfill targets and landfill taxes,[63] but reporting in each phase of the lifecycle is another relevant example.[64] As explained in the VFG Chapter, overall in both Member States, some of the tools that are greatly missing are those concerning reporting requirements on products. Both the Netherlands and Croatia are lacking reporting requirements for treatment facilities and products made from end-of-waste materials, as well as a database where all this information would be gathered and synthesized. The absence of this system (and what would be its resulting insights) makes it difficult or impossible to track progress on closing feedback loops for the bio-resources contained in both VFG. We have no insight into what quantities of VFG waste achieve end-of-waste status, what quantities are made into fertilizer products, what quantities are made into bioplastics or energy, nor what quantities in the end (still) end up landfilled.

8.3 Concluding Thoughts

A 2019 PwC report defined the circular economy as a re-organisation of the economy in a way that mimics nature, whereby 'nothing is wasted and value creation is maximised' and where 'all materials re-enter the system in a continuous cycle, thus decoupling economic activity from the consumption of finite resources.'[65] 'Decoupling' has been an aim in EU environmental policy as early as 1973, and it has been achieved to some degree (with GDP now increasing at higher rate than resource extraction).[66] For now, this decoupling is relative not absolute.

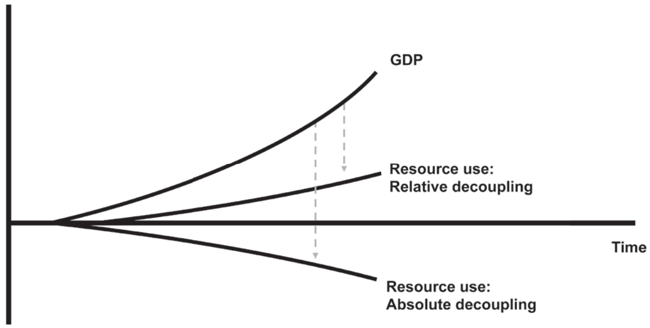
[63] See section 7.2 of the Empirical Research Results Chapter (Chapter 7).

[64] See section 7.3 of the Empirical Research Results Chapter (Chapter 7).

[65] PwC Report, 'The road to circularity' (2019).

[66] Declaration of the Council of the European Communities and of the representatives of the Governments of the Member States of 22 November 1973 on the programme of action of the European Communities on the environment, OJ/C112/1, Chapter 2; European Environmental Agency, 'Relative decoupling of resource use and economic growth in the EU-15' (November 2012).

Figure 11: Absolute vs relative decoupling of economic growth from resource use[67]



If the EU wants to remain within the planetary boundaries and achieve the regenerative growth model that the 2nd iteration of the Circular Economy Action Plan calls for, one of its aims should be achieving absolute decoupling of economic development from resource extraction.[68] In order to achieve this the highest levels of the EU waste hierarchy need to be the focus (prevention and reduction).[69] As this research has found, relatively little of the EU and national legislation surrounding circularity of VFG and sludge materials directly address over-consumption of virgin resources as a root cause of our linear economic model. Even though the circular economy is (at least partly) a strategy for sustainable development it has not yet managed to absolutely decouple itself from the continued growth model and the continued consumption of finite resources, such as those discussed for the waste streams of the present research.

From the onset, the present research has taken the circular economy as a given objective of the European Union, leaving the discussion of its merits and plausibility to other scholars.[70] However, if the circular economy is to be taken seriously in respect to its ambitious objectives, more stringent requirements need to be set. Out of all the reviewed legal and policy tools, it seems the tool that would encourage the greatest change and create the most feedback loops across the entire lifecycle of these materials is the waste hierarchy (if it were

67 Carlos Tapia et. Al. 'ESPON CIRCTER – Circular Economy and Territorial Consequences Applied Research. Final Report' (May 2019), 24.

68 M. Li, T. Wiedmann, K. Fang, and M. Hadjikakou, 'The role of planetary boundaries in assessing absolute environmental sustainability across scales', Environment international 152 (2021): 106475.

69 Ellen Macarthur Foundation, 'How the circular economy can help us stay within planetary boundaries'.

70 J. Kirchherr, D. Reike, and M. Hekkert. 'Conceptualizing the circular economy: An analysis of 114 definitions.' Resources, conservation and recycling 127 (2017): 221-232; H. Corvellec, A.F. Stowell, and N. Johansson, 'Critiques of the circular economy'. Journal of industrial ecology 26, no. 2 (2022): 421-432; Prendeville, Sharon, Chris Sanders, Jude Sherry, and Filipa Costa. 'Circular economy: is it enough.' *EcoDesign Centre, Wales* 21 (2014); J. Voorter, et. Al. 'The concept "Circular Economy": Towards a more universal definition.' (PhD Dissertation, 2022).

legally binding, where possible). As discussed in Chapter 3 however, the waste hierarchy is not legally binding and the choice of which treatment methods to apply is entirely at the discretion of Member States.

Obviously, it is not possible for the waste hierarchy to be completely binding for all materials in all parts of their lifecycle. Sometimes it is necessary to recycle, recover and even dispose (as this research has discussed). However, there are certainly instances where resources are currently being incinerated or disposed of (with significant additional material inputs of energy, and significant greenhouse gas emissions), when the waste of these resource could instead be prevented or the resources could be recovered. Remaining with the VFG and sludge material streams as an example, the Netherlands is currently incinerating a lot of its sewage sludge (with energy recovery). This is positive because it is preferred over disposal through landfilling. However, if the waste hierarchy was binding the burden of proof would be on the Netherlands to demonstrate that each higher action level of the waste hierarchy was not possible. If it demonstrated that prevention was not possible it would then have to demonstrate why preparing for re-use was not possible, then why recycling was not possible, then why recovery of resource streams was not possible, and only then could it justify its decision to proceed with incineration (for energy recovery).

The requirement would be strongest if economic justifications were, in general, not accepted as reason enough to move to a lower level of the waste hierarchy. The Netherlands was used as an example here, though the same would apply to Croatia's landfilling of VFG. These are the instances in which a binding waste hierarchy, where the highest possible action level is enforced, would stimulate a move towards absolute decoupling and enhanced resource conservation. In practice, this burden of proof would probably be with different stakeholders in different phases of the lifecycles (rather than the member state as a whole) and would vary per waste stream and per application.

Some EU member states have already taken legislative action that alludes to making (part of) the waste hierarchy legally binding. Germany has targeted the 'treatment' part of the sewage sludge lifecycle by making phosphorus recovery obligatory in its 2018 revised sewage sludge Ordinance.[71] The Ordinance made the process obligatory for all larger German wastewater treatment plants, which now have to recover phosphorus if the sludge contains more than 2% phosphorus dry solids; otherwise, they have to incinerate the sludge in mono-incinerators.[72] These measures make recovery for material streams mandatory (where possible) and make energy recovery mandatory when material recovery is not possible. Thereby ensuring that the higher levels of the waste hierarchy are applied whenever it is possible and that disposal at landfill really is a last resort, to be used only when all other options have been exhausted.

71 Already discussed in section 7.4.4 of Empirical Research Results Chapter (Chapter 7); European Sustainable Phosphorus Platform (2020).

72 European Sustainable Phosphorus Platform (2020).

An example relevant to the VFG stream was put into force in France in 2016, in the form of its food waste law. The law forbids supermarkets from destroying unsold food products, compelling them to donate them instead.[73] Though the law does not mention the waste hierarchy, it certainly is a legally binding iteration of it. The law targets retailers, and mandates that they comply with waste prevention (the highest level of the waste hierarchy).

If the EU waste hierarchy was a binding requirement (as far as possible, as in the examples given above) it would have a large impact across the entire VFG and sludge materials lifecycle – and on other waste streams. At the very beginning of the cycle virgin raw materials would be conserved because producers would have access to more of the non-virgin resources already available within our economies (because more of them would have to be recovered in alignment with the waste hierarchy). Collection would be improved because investment in better collection and separation systems would be proportional to the objectives of the waste hierarchy. Treatment would be improved most directly because treatment methods would be elevated to a higher level of the hierarchy and products/materials would be cycled back into the economy at their highest possible value, meaning the 'narrowest' feedback loop. Finally, products would be improved because the limited supply of virgin resources would create markets for recovered materials and products higher up on the bio-based value pyramid.

In order for the waste hierarchy to be more legally binding at the EU level a complex subsidiarity assessment would have to take place. It would be complex because the EU Member States have been known to push back against greater EU intervention in the area of waste law on the ground of subsidiarity and individual national circumstances in the waste sectors. For this reason, among others, it is possible that this strong driver of circularity will never become binding. However, recent EU case law addressing subsidiarity argumentations has left some space for these kinds of developments. The European Court of Justice found, in an Estonian case, that the type of individual, national circumstances used by Estonia to argue against EU intervention, do not necessarily result in a negative subsidiarity assessment.[74] The court found that the circumstances in an individual Member State cannot be obstacles to EU regulation because while some Member States may have circumstances requiring less EU action, other Member States might have situations that do require EU regulation to be resolved (in order to achieve the desired objective). Further to this, recent legislative proposals such as the Eco-design Regulation amending the Eco-design Directive, also indicate a push for stronger, more directly applicable regulations relevant to products in the circular economy.

If such a binding, directly applicable approach to the waste hierarchy were to become law it would contribute significantly to material recirculation

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73 LOI n° 2016-138 du 11 février 2016 relative à la lutte contre le gaspillage alimentaire.

74 Case C-508/13 Republic of Estonia v European Parliament and Council of the European Union [2015] ECLI 403; Huysmans, van den Brink, and van Gruisen (2023) 12.

post-consumer use and provide concrete regulatory ground for the advancement of circularity objectives across the EU.

While the EU Member States prepare their waste systems and end-of-waste markets for circularity driven change of this nature, the other lighter recommendations in section 8.5 and 8.6 can help lay the groundwork and fill some of the existing legislative gaps.

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European Parliament and Council Regulation 2019/1009 laying down rules on the making available on the market of EU fertilising products (Fertilizer Products Regulation) [2019] OJ L170/1.

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Government-wide programme for a Circular Dutch Economy by 2050, the Ministry of Infrastructure and the Environment and the Ministry of Economic Affairs, September 2016, 41, 42, 43.

Implementing Decree Fertilizers Act 2005 (Dutch: Uitvoeringsbesluit Meststoffenwet, UBMW).

LAP3, Sectorplan 06; Gescheiden ingezameld/afgegeven groente-, fruit- en tuinafval van huishoudens.

LAP3, Sectorplan 16 Waterzuiveringsslib, 'Minimumstandaard voor vergunningverlening (a)' (Eng: Sectorplan 16 Sludge Water treatment, 'Minimum standard for licensing (a)'), p. 1.

Law on Waste Management (Hr: Zakon o gospodarenju otpadom, ZGO), NN 84/2021.

LOI n° 2016-138 du 11 février 2016 relative à la lutte contre le gaspillage alimentaire.

Nacionalna razvojna strategija Republike Hrvatske do 2030. godine (Eng: National development strategy of the Republic of Croatia until 2030).

Odluka o donošenju Plana gospodarenja otpadom Republike Hrvatske za razdoblje 2017. - 2022. godine, NN 1/2022, Section 7.1, Table 14.

Ordinance of the Provincial Council of South Holland of 20 February 2019 (PZH-2019-677696264) containing rules on the protection and use of the physical living environment (Environmental Ordinance South Holland) <https://decentrale.regelgeving.overheid.nl/cvdr/xhtmloutput/Historie/Zuid-Holland/CVDR622914/CVDR622914_2.html> Accessed 1st June 2023.

Pravilnik o gospodarenju muljem iz uređaja za pročišćavanje otpadnih voda kada se mulj koristi u poljoprivredi NN 38/2008 (Eng: Rulebook on the management of sludge from wastewater treatment plants when the sludge is used in agriculture).

Pravilnik o registraciji subjekata i odobravanju objekata u kojima posluju

subjekti u poslovanju s nusproizvodima životinjskog podrijetla (2022, 20/10).
Pravilnik o nusproizvodima i ukidanju statusa otpada NN 117/2014 (Eng: Rulebook on by-products and abolition of waste status).
Pravilnik o nusproizvodima životinjskog podrijetla koji nisu za prehranu ljudi (87/09).
Pravilnik o uvjetima odlaganja otpada, kateIorijama i uvjetima rada za odlagališta otpada NN 117/2007 (Eng: Rulebook on waste disposal methods and conditions, categories and operating conditions for waste disposal sites), Article 5 (1).
Pravilnik o zaštiti poljoprivrednog zemljišta od onečišćenja NN 71/2019 (Eng: Rulebook on the protection of agricultural land from pollution).
Prijedlog zakona o gnojidbenim proizvodima (Eng: Proposal of the law on fertilizing products) <https://www.sabor.hr/sites/default/files/uploads/sabor/2022-07-07/144001/PZE_307.pdf> Accessed 1st May 2023.
Sectorplan 16 Waterzuiveringsslib, 'Minimumstandaard voor vergunningverlening (a)' (Eng: Sectorplan 16 Sludge Water treatment, 'Minimum standard for licensing (a)').
Staatsblad van het Koninkrijk der Nederlanden, Article 1(4).
Strategy Governing Raw Materials in the Republic of Croatia (Croatian: Strategija Gospodarenja Mineralnim Sirovinama Republike Hrvatske), March 2008.
VANG-HHA, 'Het programma: Met optimale afvalscheiding naar hoogwaardige recycling' (VANG Website, 2023) <https://vang-hha.nl/programma/> Accessed 1st August 2023.
Wet Milieubeheer (Eng: Environmental Conservation Act).

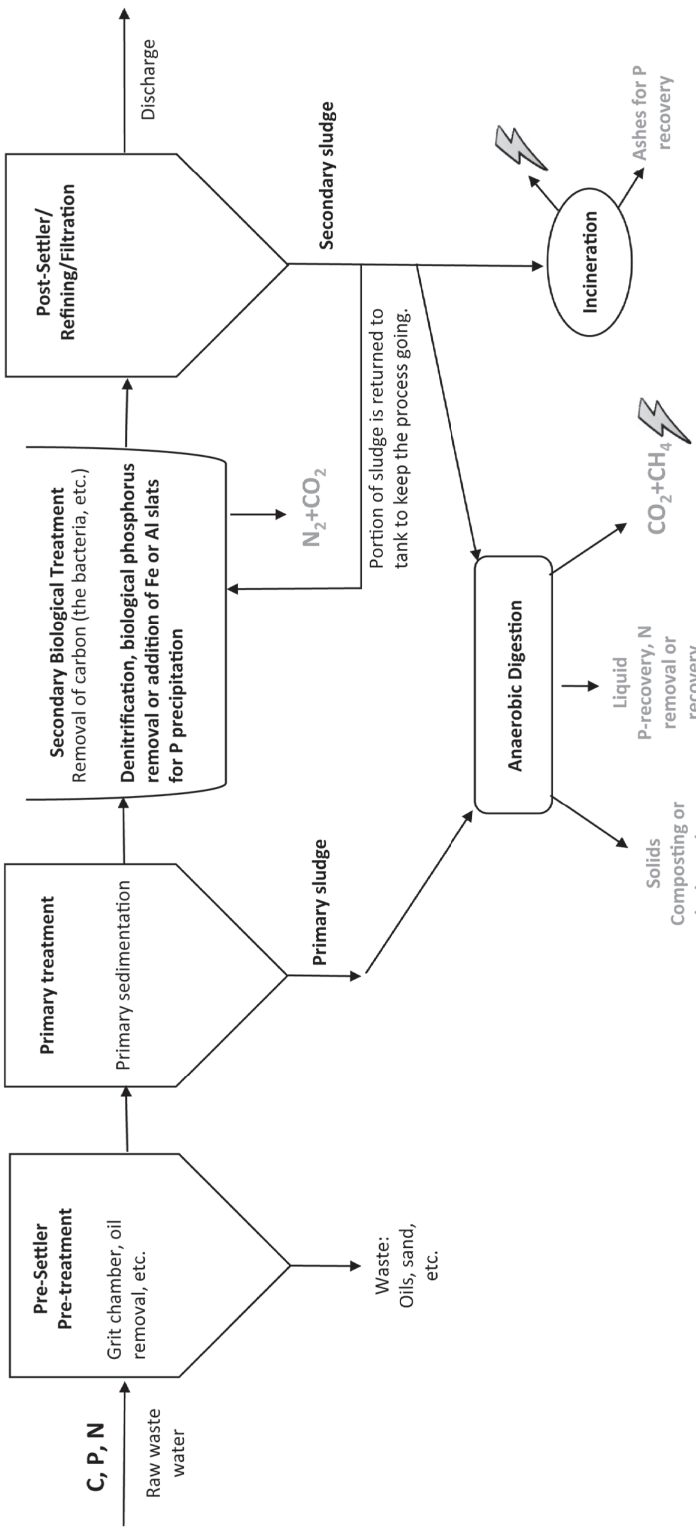
Appendix 1
Interview Categories and Institutions/Companies of Each Inter-View Participant

Appendix 1 - Interview categories and institutions/companies of each interview participant

	EU	HR		NL	
		Public	Private	Public	Private
VFG Collection	/	Municipality in Čakovec	Local waste service in Čakovec	Municipality in Den Haag	Local waste service in Den Haag
		Municipality in Gospić	Local waste service in Gospić	Municipality in Zwolle	Local waste service in Zwolle
Sludge Collection	/	Waste Management Consultancy		STOWA (National knowledge centre for water boards)	
VFG/ Sludge Recycling	European Compost Network	Ministry of Econ. Affairs and Sustainability	Compost Industry	Directorate General for Public Works and Water Management	Engineering consultancy
Fertiliser Products	EU Env. DG, 'From Waste to Resources'	FZOEU (Env. Protection and Energy Efficiency Fund)	Bio-resource Consultancy	Ministry of Agriculture	Secondary raw materials company[1]
Bioplastics Products	EU Env. DG, 'Sustainable Products'	Ministry of Agriculture	Bio-plastic producer	Ministry of Infrastructure and Water Management	Bio-plastic producer

1 This is a company that works on helping companies develop markets for their secondary raw materials.

Appendix 2
Sludge Treatment Diagram


C, P, N
Raw waste water
Pre-Settler
Pre-treatment
Grit chamber, oil removal, etc.
Waste:
Oils, sand, etc.
Primary treatment
Primary sedimentation
Primary sludge
Secondary Biological Treatment
Removal of carbon (the bacteria, etc.)
Denitrification, biological phosphorus removal or addition of Fe or Al slats for P precipitation
N_2+CO_2
Portion of sludge is returned to tank to keep the process going.
Post-Settler/
Refining/Filtration
Discharge
Secondary sludge
Incineration
Ashes for P recovery
Anaerobic Digestion
CO_2+CH_4
Liquid
P-recovery, N removal or recovery
Solids
Composting or incineration

Appendix 3
Municipality-Specific Data on VFG Waste Collection in the Netherlands

As described in the above chapter, there are a variety of different legal and policy instruments which are, or could be, used in municipal policies and waste collection plans to improve VFG collection. These were Information, Collection (Kerbside and Dropoff), variable rates of waste collection charges, Industry Subsidies, and Penalties (for Collectors and for Individual Households). The present research looked at the application of these instruments to the separate collection of VFG in the two Dutch provincial capitals and in two Dutch municipalities with a low population and low population density. A breakdown of each municipality's use of the various instruments is provided below.

Information

Den Haag

Den Haag does provide information on its website that facilitates easier waste separation for its citizens. This includes information on how to separate waste (list of different waste streams and bullet point lists of loosely what falls under each stream), schedules for kerbside waste collection by postcode area, maps of various waste dropoff points, and arrangements for bulky garden waste collection.[1] For this reason, Den Haag is given a '2' for this instrument, as there is plenty of detailed information on how to separate waste and dispose of it. Improvements could be made in the visual display of the information.

Westvoorne

The Westvoorne website provides the most clear and accessible information of the four provinces reviewed here. The website distinguishes between the different types of waste collection available to citizens in different parts of Westvoorne, it offers a personal waste calendar by postcode, and it explains the different waste streams that should be separated.[2] The personal waste calendar app provides further information on what waste materials fall under which waste stream, as well as other useful tips for correct separation of waste.[3] The website could be improved if some of this information, such as the different types of waste that fall under 'VFG' and other waste streams, was already clarified on the website, rather than just in the app. An additional benefit for the consumers is an 'Updates' page on the topic of waste, on which they can be informed of changes to the municipal waste policies in a timely manner.[4] For these reasons, Westvoorne is given a '2' for this instrument.

1 Den Haag Municipality, 'Waste and Recycling' (Den Haag Municipality Website, November 2020), <https://www.denhaag.nl/en/waste-and-recycling.htm> Accessed 1 June 2023.

2 Westvoorne Municipality, 'Minicontainers' (Westvoorne Municipality Website, November 2021) <https://www.westvoorne.nl/minicontainers> Accessed 1 June 2023.

3 Westvoorne Municipality, 'Afvalwijzer' (Westvoorne Municipality Website, November 2021) <https://www.westvoorne.nl/afvalwijzer> Accessed 1 June 2023.

4 Westvoorne Municipality, 'Update Inzameling Grofvuil' (Westvoorne Municipality Website, February 2021) <https://www.westvoorne.nl/update-inzameling-grofvuil-11-februari-2021> Accessed 1 June 2023.

Zwolle

Zwolle's municipal website on waste does provide some relevant and current information about waste separation. The municipality is in momentarily influx as it attempts to introduce a waste separation rewards system (akin to pay-as-you throw). The website does its best to keep citizens up-to-date on this new initiative through a page on 'Zwolle Without Waste' (which specifically addresses the contribution of waste separation to circular economy and reuse targets) and a page on 'Waste separation apartments and compact neighbourhoods'.[5] However, all additional information on how to separate waste and when said waste will be collected is left to the ROVA collection company's website, to which links are provided.[6] Additionally, the municipal website does not offer any clarity to citizens on the different types of waste collection and dropoff, relevant to their given location. For these reasons, Zwolle is given a '1' for this instrument, as there is some information on latest policy updates but the basics of waste separation, which should be easily accessible to individuals, are not provided on the municipality's website.

Ommen

Ommen does provide information on its municipal website that gives households some information on waste collection, including collection times for various waste streams and costs of collection (per plot of land). However, the information is not continually updated, with some information such as that on rates dating back to 2018 (there have been two municipal regulations on taxation rates since then). Furthermore, the presentation is a bit old and it can be difficult to find the necessary information. There is no information on the municipality's own website on how to separate waste, for example what types of waste fall under 'VFG' waste. However, a link is provided to the website of the company that collects waste in Ommen, where more information is given on what waste belongs in what bin, as well as where the collection containers and centres are located. For these reasons, Ommen is given a '1' for this instrument, as there is there is some information, but it is not very detailed and not very easy to navigate.

Collection – Kerbside

Den Haag

Den Haag does collect VFG waste door-to-door, or 'kerbside', in some neighbourhoods – predominantly areas with low-rise buildings.[7] The HMS (Haagse Milieu Services) collects VFG household waste in Den Haag, in about one-third of Den Haag's municipal territory.[8]

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5 Zwolle Municipality, 'Afval' (Zwolle Municipality Website, November 2021) <https://www.zwolle.nl/afval> Accessed 1 June 2023;

6 Ibid.

7 Haags Milieucentrum (2008) 9.

8 Den Haag Council (2015) 9.

In the past Den Haag has struggled to implement source separation of VFG and other organic waste, with the municipality reporting that the results of previous attempts are disappointing in urban areas, and have therefore been discontinued.[9] The municipality has also not been able to achieve organic waste separation from residual waste subsequent to collection. From these efforts, the municipality initially drew the conclusion that the national target of 75% waste separation was not feasible in Den Haag.[10] To improve its chances of meeting the targets by 2020, Den Haag instead chose to focus on non-organic separately-collected waste streams, such as paper, glass, textile, plastic and chemical waste.[11] For these reasons, Den Haag is given a '1' for this instrument, as kerbside collection exists but is not widely available for the VFG waste stream.

The municipality further justified this decision in 2016 by explaining that the environmental efficiency of waste separation and reprocessing is not the same for all waste fractions.[12] Highlighting how environmental return for the reuse of organic waste (in grams of CO_2 emissions per kilo) are much lower that the environmental returns of reuse for other waste streams, like plastic or textile – making reuse of these streams more profitable. This seems to be a low priority issue for separate collection of VFG, which could cause problems concerning compliance with new articles in the WFD (which are likely to include targets for separate collection of VFG). At the time of writing the 2016 Household Collection Plan, Den Haag's municipal government believed to be on track to achieving this target even without the realisation of separate organic waste collection throughout the whole municipality.[13] *At the moment, there are not yet numbers out on whether or not they have achieved this, but I will keep an eye on this throughout the remaining years of my PhD, as I am sure there will be updates on this.*

Westvoorne

In Westvoorne, VFG is collected door-to-door in some neighbourhoods by the municipality's own waste collection services. For all households not located in high-rise apartment buildings, Westvoorne offers door-to-door collection of 'mini containers' for VFG with a capacity of 140 or 240 litres. Collection days are detailed in the municipal waste app, AfvalWijzer. For these reasons, Westvoorne is given a '1' for this instrument, as kerbside collection exists but is not widely available for the VFG waste stream.

Zwolle

Zwolle does collect VFG waste door-to-door, or 'kerbside', in various neighbourhoods. Some neighbourhoods only have collection of paper and/or plastic waste streams, while some only (or also) have collection of VFG waste. It is not

9 Den Haag Council (2015) 19.

10 Ibid.

11 Ibid.

12 Den Haag Council (2015) 22.

13 Ibid.

clear from the policy documents and sources on the internet whether Zwolle has completely phased out door-to-door collection of residual waste, forcing consumers to dispose of residual waste only in underground containers and at dropoff points. Judging by ROVA's collection calendar for Zwolle, it certainly seems that way. If this is the case, this could potentially be a measure aimed at decreasing the convenience of residual waste disposal and increasing the convenience of disposal for recycling streams (like VFG waste). However, for VFG waste, this is not consistently implemented for all neighbourhoods, as many still lack door-to-door collection of VFG.

Specifically regarding VFG waste, Zwolle's municipal ordinance requires that VFG waste be collected separately at least once every two weeks.[14] However, this does not apply to parcels that are part of a stacked construction and for which no collection resources have been found, as well as boats lost.[15] These exceptions are the reason why not all neighbourhoods have VFG collection options. As such, Zwolle is given a '1' for this instrument, as kerbside collection exists but is not widely available for the VFG waste stream.

Ommen

In the municipality of Ommen, the waste processing company ROVA collects household waste, including VFG. The municipality places an emphasis on separate collection of as many reusable materials as possible, specifically also VFG waste.[16] According to Ommen's waste ordinance, VFG waste is collected separately at least once every two weeks at each plot that is not in a high-rise building.[17] Residual waste is not collected door-to-door in most areas, but only in the 'countryside' every four weeks.[18] This setup could encourage better waste separation as residual waste is not frequently collected, and in some areas not collected door-to-door at all.[19] As such, Ommen is given a '1' for this instrument, as kerbside collection exists but is not widely available for the VFG waste stream.

14 Afvalstoffenverordening gemeente Zwolle 2011 (Eng: Municipal Waste Ordinance Zwolle 2011), Article 5

15 Afvalstoffenverordening gemeente Zwolle 2011 (Eng: Municipal Waste Ordinance Zwolle 2011), Article 3(3)

16 Ommen Municipality, 'Afval Inzameling' (Ommen Municipality Website, November 2021) <https://www.ommen.nl/inwoners/wonen/afvalinzameling.html> Accessed 1 June 2023;

17 Ibid.

18 Ommen Municipality, 'Inzameling en tarieven' (Ommen Municipality Website, November 2021) <https://www.ommen.nl/inwoners/wonen/afvalinzameling/inzameling-en-tarieven.html> Accessed 1 June 2023;

19 Ibid.

Collection – Dropoff Points

Den Haag

In areas where kerbside collection is not available, individuals have to put significantly more effort into waste separation. While there are dropoff containers scattered through neighbourhoods for paper, plastic, glass and textile, there is no such option for VFG. Instead, VFG can only be dropped off at two of the three existing waste dropoff centres in Den Haag (Plutostraat and De Werf).[20] While there is no fee for dropping off VFG waste (as there is for other waste streams like garden timber, roofing, etc), the setup still realises only minimal convenience for the individual. This is why Den Haag is given a '1' for this instrument, as dropoff points for VFG are barely existent.

Westvoorne

For households located in high-rise apartment buildings, Westvoorne offers waste separation only through neighbourhood underground containers, but these are plentiful and conveniently located.[21] All citizens are provided with VFG bins, in an attempt to make it very easy to keep food scraps and the like separate from residual waste.[22] The location of containers for various waste streams, including VFG, can be found on a map in the municipal waste app, AfvalWijzer. This is why Wetvoorne is given a '2' for this instrument, as dropoff points for VFG are present and efforts are made to ensure VFG disposal is convenient for citizens.

Zwolle

Zwolle's municipal website continually emphasises the importance of residents having the opportunity to separate waste and raw materials properly and easily.[23] One of the ways it claims to do this is through conveniently placed separate, underground collection bins throughout neighbourhoods.[24] Despite efforts, this is still not achieved in the entirety of the municipality, with a few places – like some apartment buildings and compact inner city neighbourhoods, where the houses are relatively close together – still not having convenient means of separating waste. For these reasons, Zwolle is given a '1' for this instrument, as dropoff points for VFG are still not conveniently placed for all citizens.

The municipality has said that it is actively working to remedy this as it seeks to advance its pay-as-you-throw initiative starting in January 2022. If the municipality

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[20] Den Haag Municipality, 'Separating Waste: Organic waste (GFT)' (Den Haag Municipality Website, November 2020), <https://www.denhaag.nl/nl/in-de-stad/natuur-en-milieu/afval-scheiden-en-hergebruik/groente-fruit-en-tuinafval-gft-afval.htm> Accessed 1 November 2020.

[21] Westvoorne Municipality (2021c).

[22] Westvoorne Municipality, 'Gratis Afvalbakje voor GFT' (Westvoorne Municipality Website, November 2021) <https://www.westvoorne.nl/gratis-afvalbakje-voor-gft-afval-en-etensresten > Accessed 1 June 2023.

[23] Zwolle Municipality (2021).

[24] Ibid.

wants citizens to be financially rewarded for limiting their residual waste (by putting more effort into waste separation) then they must ensure that all residents have the option to separate waste accessible to them. The municipality has said that in places where these facilities are not yet available, the municipality will ensure that they are available over the course of 2021.

Ommen

In Ommen, there do not appear to be any underground containers for VFG waste, nor does it seem that the waste dropoff centres accept VFG waste. This is strange considering that the waste centres collect just about all other types of waste. For these reasons, Ommen is given a '0' for this instrument.

Variable Rates of Waste Collection Charges (Including Pay-as-you-throw)

Den Haag

There are no pay-as-you-throw initiatives for residual waste in Den Haag, as tax rates differ only by housing plot location where waste streams are collected door-to-door and where they are not. As such, Den Haag is given a '0' for this instrument.

Westvoorne

There are no pay-as-you-throw initiatives for waste in Westvoorne, as tax rates differ only by housing plot location where waste streams are collected door-to-door and where they are not. As such, Westvoorne is given a '0' for this instrument.

Zwolle

As briefly mentioned in the earlier paragraphs, from the first of January 2022 Zwolle plans to introduce a pay-as-you-throw initiative, called 'Zwolle rewards'. The idea behind the initiative is that residents who separate their waste properly, and therefore throw away less residual waste are rewarded by having to pay a lower waste tax, while residents who throw away more residual waste should pay higher waste taxes.[25] This initiative would apply to all citizens, with some specific exceptions made for households in financial difficulties and households with an above-average amount of residual waste (due to, for example, the use of diapers or large amounts of medical materials).[26] For these reasons, Zwolle is given a '1' for this instrument, as it is working to implement it.

Despite the positive targets, 'Zwolle Rewards' has been the target of some pushback from political parties like the PvdA, D66 and SP, who voted against the city Council's proposal of the plan, on the grounds that it remains unclear what measures are being taken to enable all residents to separate their waste.[27] This

[25] Ibid.

[26] Ibid.

[27] Ibid.

is an understandable critique considering the issues described above in terms of providing accessible waste separation opportunities for all citizens. The municipality of Zwolle will continue to work to resolve these problems in 2021.

Ommen

There are no pay-as-you-throw initiatives for waste in Ommen, identified under that specific name. However, Ommen does have a rather specific set of financial rates for disposal of various waste streams. In addition to a standard tax rate per plot (to which there is a difference depending on whether VFG and other waste streams are collected separately or not), there are also rates for emptying of residual bins which are calculated 'per emptying'.[28] Thus, for example, emptying of a grey mini-container or city bin of 240 litres costs €9.21 per emptying. Such specifications are given for all the different-sized bins, with a clarification that this method of collection allows the consumer to directly influence the amount of waste tax they have to pay.[29] The further addition that all collection and emptying of VFG and plastic waste is free further indicates that the system in place in Ommen is a type of pay-as-you-throw, designed to limit the amount of residual waste discarded by households.[30] As such, Ommen is given a '1' for this instrument, as it is present to a degree under a different name.

Industry Subsidies

The Netherlands is no stranger to industry subsidies, of which there are several relevant to waste and the environment. These are all put in place at the national level, but mostly executed at the municipal level.[31] A prime example is the Waste Fund (Afvalfonds), which was developed by the Ministry of Environment, the Association of Dutch municipalities and the packaging industry.[32] The Fund allows all municipalities to receive an amount from the Waste Fund to facilitate the separate collection of packaging waste from households. There is no such equivalent for VFG waste.

The use of subsidies is, to some extent, in conflict with the 'polluter pays principle'. However, studies on this topic of a more economic nature have deemed that 'under certain conditions, the use of subsidies can be a justifiable exemption to the general 'polluter pays principle' in environmental policy', specifically when 'it is impossible to internalise the full external costs of a product over its entire lifecycle'. Food, and specifically the food which ends up in the VFG waste stream, is an example of such a product – making the VFG stream a good candidate for

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28 Ommen Municipality (2021) 6.

29 Ibid.

30 Ibid.

31 Frans H. Oosterhuis, Heleen Bartelings LEI and Vincent GM Linderhof LEI, 'Economic instruments and waste policies in the Netherlands' (Report for Ministry of Housing, Physical Planning and the Environment, 2009), p. 75.

32 Oosterhuis, Frans, Van Beukering & Linderhof (2009), p. 75.

subsidies on reuse, throughout the whole production cycle (including collection).[33] As such, for now, all four municipalities are given a '0' for this instrument.

Penalties – for Collectors

I could not find any penalties for collectors mentioned in any of the documents from the four Dutch municipalities or at the national level. However, for now, all four municipalities are given a '0' for this instrument.

Penalties – for Individuals/Households

Den Haag

While penalties for individuals due to improper waste disposal do exist in Den Haag, they are only issued for putting household rubbish out too early or too late, placing household rubbish in the wrong spot or placing bulky waste on the street without appointment.[34] There is no system to determine incorrect sorting or penalise incorrect sorting, which is why Den Haag is given a '0' for this instrument.

Westvoorne

The municipality of Westvoorned does mention on its website that a failure on the part of households to separate their waste could result in a fine, which is why Westvoorne is given a '1' for this instrument.[35] However, there is no mention of this in the waste regulation nor are any further specification listed on how this is carried out and enforced.

Zwolle and Ommen

The municipalities of Zwolle and Ommen do not mention on their website or in the municipal ordinances any fines for incorrect sorting of waste. However, as discussed above, both municipalities have some form of pay-as-you-throw scheme in place, meaning that citizens are technically 'fined' if they have too much residual waste. This can be considered a penalty to some extent, although it is not the same as a fine for incorrect sorting or contamination of waste streams. As such, both municipalities are still only given a '0' for this instrument, as it is not explicitly applied.

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33 'Food prices are kept artificially low, among others by means of reduced VAT rates. Moreover, farmers do not pay for most of the environmental damage caused by their activities (such as the eutrophication of surface and ground waters, and the contribution of livestock's CH4 and N2O emissions to global warming). As a result (and despite the recent price increases on the world market) food remains 'too cheap', providing incentives for wasteful behaviour'; Oosterhuis, Frans, Van Beukering & Linderhof (2009), p. 77.

34 Den Haag Municipality, 'Penalty for Improper Waste Disposal' (Den Haag Municipality Website, November 2020), <https://www.denhaag.nl/en/waste-and-recycling/household-rubbish/penalty-for-improper-waste-disposal.htm> Accessed 1 November 2020.

35 Westvoorne Municipality (2021b).

Appendix 4
Municipality-Specific Data on VFG Waste Collection in Croatia

As described in the above chapter, there are a variety of different legal and policy instruments that are, or could be, used in municipal policies and waste collection plans to improve the collection of VFG. These were: Information, Collection (Kerbside and Dropoff), Pay-as-you-throw, Industry Subsidies, and Penalties (for Collectors and for Individual Households). The present research looked at the application of these instruments to the separate collection of bio-waste in four cities, belonging to two separate counties – two cities in each county. The four cities were the two respective county capitals and the two LSGUs in each county with a low population and low population density. A breakdown of each of the LSGUs' use of the various instruments is provided below:

Čakovec

There is a link to a page about 'waste management' on the homepage of the Čakovec LSGU's website, however the link is broken.[1] Some information for citizens can be found on the website of the service provider Čakom, but it is still largely in the format of large, legal documents and decisions, rather than a user-friendly, informative interface. Čakom has, however, developed an app that promises to provide clarity for citizens on waste separation and disposal.[2]

In addition to the website, the report on the execution of Čakovec's waste management plan gives insight on a variety of initiatives they have put in place to educated citizens about waste separation.[3] These include cooperation with civil ecological organisation to encourage waste prevention, education about different types of waste, opportunities for recycling of different waste, bio-waste and composting. The LSGU believes the citizens' high level of familiarity with waste management comes from the fact that Čakovec has been separately collecting different waste streams for over 15 years, during which educational/informative activities and workshops related to waste were continuously offered and attended by citizens.[4] The informative activities also went beyond workshops, to include educational TV adverts, radio jingles, notices on community print media, and distribution of leaflets to individual households.[5]

Some of the weaknesses around information, identified by the LSGU itself, include: a lack of information about waste management in some areas of the population (particularly the Roma minorities); a perspective from the point of view of citizens that waste is a problem that should be solved by someone else, and; an oversimplified understanding of waste management problems.[6] Furthermore, the plan itself is highly focussed on educating the citizens on waste management,

1 Čakovec Municipality Website <https://www.cakovec.hr/web/> Accessed 1 June 2023;

2 Čakovec Waste Service Provider Website <https://www.cakom.hr/> Accessed 1 June 2023;

3 Čakovec Municipality, 'Plan Gospodarenja Otpadom Grada Čakovca za razdoblje 2018 do 2023 godine' (Čakovec Municipality Document, December 2017) <https://www.esavjetovanja.cakovec.hr/dokumenti/nacrti/Nacrt_PGO_Grada_Cakovca.pdf> Accessed 1 July 2023.

4 Ibid.

5 Ibid.

6 Ibid.

while relatively little reflection is provided by the LSGU as to other instruments which are available to stimulate separate collection – such as subsidies for industry, penalties for collectors, or penalties for individuals.

For these reasons, Čakovec is given a '2' for this instrument, as there is plenty of detailed information provided to citizens on how to separate waste and dispose of it. In the future, Čakovec could perhaps provide more online information, which citizens can access at any time, in addition to the app and education initiatives. Beyond information, Čakovec could reflect more on the role that different instruments could play in improving its waste management.

Dekanovec

Dekanovec does provide information on its own LSGU website about waste management and collection, but it is also largely in the form of legal documents and various local decisions, as opposed to a user-friendly interface that could facilitate better waste sorting.[7] The service provider PRE-KOM does provide some information about separating waste on its website, and it appears that these are also the leaflets they send-out to individual households.[8]

In addition to online information PRE-KOM also organises some educational activities in Čakovec to improve waste separation.[9] They organised educational workshops for children in school and pre-school (for around 500 children per year), and they also organise various community waste-clearing projects, as well as informative seminars on how to separate different waste streams, including bio-waste.[10]

Gospić

The official webpages of Gospić LSGU do not contain anything by-way of information on separate waste collection targeted at citizens.[11] However, the service provider 'Komunalac Gospić' does provide some limited information on its website, though this is only about the collection of residual waste and paper waste (the only streams which are collected in Gospić).[12] Any additional information about the importance of waste separation, including bio-waste, is only provided on websites of EU-funded projects. For this reason, Gospić is given a '0' for this instrument.

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7 Dekanovec Municipality Website <https://www.dekanovec.hr/web/informacije/gospodarenje-otpadom > Accessed 1 June 2023.

8 Dekanovec Waste Service Provider Website <https://www.pre-kom.hr/files/letak-otpad-2019.pdf> Accessed 1 June 2023.

9 Dekanovec Municipality, 'Plan Gospodarenja Otpadom za razdoblje 2017 do 2022' (Dekanovec Municipality Document, February 2017) <http://dokumenti.azo.hr/Dokumenti/PGO_Opcina_Dekanovec_za_razdoblje_2017_2022.pdf> Accessed 1 July 2023, p. 34.

10 Ibid.

11 Gospić Municipality Website <https://gospic.hr/> Accessed 1 June 2023.

12 Gospić Waste Service Provider Website <https://komunalac-gospic.hr/#> Accessed 1 June 2023.

Lovinac

Seeing as Lovinac does not perform separate collection of bio-waste, there is no need to have educational information on separation of waste for citizens on their website, which is why it is not provided. This is something Lovinac will work on, but at the moment it is tackling what it deems are bigger problems related to waste, including:[13]

-the replacement of waste collection vehicles;

-sanitation of illegal dumping sites;

-working to reduce waste creation.

Lovinac does list 'strengthening the awareness of the local population about the importance of environmental protection' as one of its key goals related to waste management.[14] The LSGU plans to achieve this through educational and informative activities, lectures and eco-actions.[15] Though some plans are being developed, these are minimal, and citizens are not sufficiently informed of the need to separate waste or how to do it. For this reason, Lovinac is given a '0' for this instrument.

Collection – Kerbside

Čakovec

There is a long-standing practice of waste separation in Čakovec when it comes to kerbside collection, with a particular emphasis on separate collection of bio-waste.[16] Bio-waste is collected from homes every two weeks, while in high-rise buildings (which have a higher number of citizens) bio-waste is collected twice every week. Citizens can request that their bio-waste be collected more often through the use of additional coupons. At the start of each year, every household is given two coupons for an additional collection of bio-waste (2m3 per coupon).[17] Čakovec is given a '2' for this instrument, as kerbside collection does exist and is available even in high-rise buildings, and for additional pick-ups via the coupon system.

Dekanovec

Dekanovec does provide kerbside collection, but not for all citizens in the LSGU. Since 2016, Dekanovec has been running a pilot project for bio-waste collection for those households that wish to take part (i.e. it is optional). For the 30% of the

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13 Lovinac Municipality, 'Razvoj i unaprijeđenje sustava zbrinjavanja otpada' (Lovinac Municipality Website, 2020) <https://www.lovinac.hr/page/razvoj-i-naprijedenje-sustava-zbrinjavanja-otpada> Accessed 1 June 2023.

14 Ibid.

15 Ibid; Ličko Senjska Županija, 'Izvjesće o provedbi PGO Licko senjske županije 2019' (Provincial documents, May 2020) <http://dokumenti.azo.hr/Dokumenti/Izvjes%C4%87e_o_provedbi_PGO_Licko_senjske_zupanije_2019.pdf> Accessed 1 June 2023, 8.

16 Čakovec Municipality, (2017)

17 Ibid.

population that has opted into the pilot project, bio-waste is collected once every two weeks in bins of 120 litres. Bigger bins are available upon request. In its waste management plan, Dekanovec does not group bio-waste into the ‘useful waste’ category, alongside paper, plastic and glass. This shows that the full waste cycle for bio-waste is not fully enshrined in the thinking around waste management in the Dekanovec LSGU. For this reason, Dekanovec is given a ‘1’ for this instrument, because kerbside collection is present, but it is not widely available.

Gospić

According to the Gospić LSGU’s waste management report for 2019, no non-residual waste streams are collected door-to-door. No plans to improve this system are mentioned in either the 2019 report or the more long-term waste management plan.[18] This is not sufficient to meet compliance requirements with national legislation on waste management. For these reasons, Gospić is given a ‘0’ for this instrument.

Lovinac

As explained in their waste management report, Lovinac does not have a system in place for door-to-door collection of bio-waste. Instead, the LSGU relies entirely on small-scale community composting for the disposal of bio-waste. This is not sufficient and does not meet the compliance requirements with national legislation on waste management. For these reasons, Lovinac is given a ‘0’ for this instrument.

Collection – Dropoff Points

Čakovec

In addition to the kerbside collection, Čakovec also offers its citizens the opportunity to bring waste to two recycling yards: Čakovec and Totovec.[19] In addition to this, there is also a service of mobile recycling yards, which function on a specific schedule in each neighbourhood and in which citizens can dispose of different waste streams.

It should also be noted that though Čakovec does have ten ‘green islands’ at which citizens can deposit separately-collected waste (paper, glass, plastics, metals), these islands do not include a dropoff point for bio-waste.[20]

Dekanovec

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[18] Gospić Municipality, ‘Izvješće o provedbi plana gospodarenja otpadom u 2020. godini’ (Ličko Senjska Županija Document, May 2020) <https://gospic.hr/sluzbeni-vjesnik-grada-gospica/sluzbeni-vjesnik-grada-gospica-broj-5-2020/izvjesce-o-izvrsenju-plana-gospodarenja-otpadom-grada-gospica-za-2019-godinu/> Accessed 1 June 2023.

[19] Čakovec Municipality (2017)

[20] Ibid.

In addition to the kerbside collection, citizens in Dekanovec can also bring their bio-waste to the treatment centre, but this does come with additional charges.[21] The waste management plan does mention that all legal entities as well as the municipality itself must dispose of biodegradable waste in accordance with the national legislation (i.e. composting in composting plants),[22] though it is not clear how this is expected to be achieved when neither door-to-door collection or dropoff points are made widely available to citizens. For this reason, Dekanovec is given a '1' for this instrument.

Gospić

According to the Gospić LSGU's waste management report from 2019, there are no bio-waste dropoff points on the territory of the LSGU.[23] This is not sufficient to meet compliance requirements with national legislation on waste management. For these reasons, Gospić is given a '0' for this instrument.

Lovinac

In the Lovinac LSGU, citizens have access to ten 'green islands' to which they can bring various non-residual waste such as glass, plastic and paper. However, these green islands do not provide containers for bio-waste.[24] For this reason, Lovinac is given a '0' for this instrument. Lovinac is not in compliance with the EU or national waste legislation on separate collection of bio-waste.

Variable Rates of Waste Collection Charges (Including Pay-as-You-Throw)

Čakovec

Since 2004, Čakovec has been working on the development of an effective pay-as-you-throw system. The project started out as a pilot, with 230 users, who each had to pay five Croatian kuna (herein: HRK) per emptied bin.[25] The project has since been expanded to include most of the neighbourhoods in Čakovec. The method for registering the amount of waste and type of waste collected has been improved through the use of RFID chip technology and automatic registration of this information in the operating system.[26] The price each household pays is truly based on the amount of 'emptyings' that the Čakovec waste service has to provide. This system is used for both residual waste and other waste streams (including paper, plastic, metals, and, importantly, also bio-waste).[27]

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21 Dekanec Municipality, 'Plan Gospodarenja Otpadom Dekanec' (Dekanec Municipal Website, February 2017) <http://dokumenti.azo.hr/Dokumenti/PGO_Opcina_Dekanovec_za_razdoblje_2017_2022.pdf> Accessed 1 June 2023, 14

22 Ibid.

23 Gospić Municipality (2020) 5.

24 Ličko Senjska Županija (2020) 8.

25 Čakovec Municipality (2017) <https://www.esavjetovanja.cakovec.hr/dokumenti/nacrti/Nacrt_PGO_Grada_Cakovca.pdf> Accessed 1 July 2023.

26 Ibid

27 Ibid.

The LSGU reflects in their 2019 report on waste management that these measures have noticeably contributed to a decrease in the amount of residual waste collected in Čakovec.[28] There is no evidence in the waste management plan or 2019 report that Čakovec has attempted to play-around with the cost of disposing different waste streams.[29] By, for example, having the price be higher for residual waste and lower (or non-existent) for other waste streams such as plastic or bio-waste. This could further decrease the total amount of collected residual waste in the future. Despite this, Čakovec does have an effective, far-reaching pay-as-you-throw system in place, so it receives a '2' for this instrument.

Dekanovec

There is no pay-as-you-throw scheme as such in Dekanovec, but Article 30 of their latest 'Decision on the manner of providing public waste collection services' does indicate that they are aware of their legal obligation to reduce the amount of mixed municipal waste, and that one of the ways to achieve this is by obliging citizens to pay a fee relative to the amount of mixed municipal waste their household produces. Even though this indicates a movement towards the development of pay-as-you-throw, Dekanovec gets a '0' for this instrument, as it is not yet in place.[30]

Gospić

There are no pay-as-you-throw initiatives for residual waste or bio-waste in Gospić. As such, Gospić is given a '0' for this instrument.

Lovinac

There are no pay-as-you-throw initiatives for residual waste or bio-waste in Lovinac. As such, Lovinac is given a '0' for this instrument.

Industry Subsidies

In Croatia, subsidies are implemented at the national level through Croatia's EU-funded FZOEU. It also appears that most of these subsidy programmes are aimed at waste treatment as opposed to waste collection, which makes sense because well-collected waste is of no use if it cannot also be well treated, according to the waste hierarchy of the EU.

All four of the reviewed LSGUs could benefit from industry subsidies at the national level (particularly Gospić and Lovinac). For now, all four LSGUs are given a '0' for this instrument.

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[28] Ibid.

[29] Ibid.

[30] Dekanovec Municipality (2017) 14.

Penalties – for Collectors

No penalties for collectors were mentioned in any of the documents from the four Croatian LSGUs, nor at the national level. All four LSGUs are given a '0' for this instrument.

Penalties – for Individuals/Households

Čakovec

In Čakovec there are legally-prescribed penalties for incorrect sorting of bio-waste.[31] Article 26 of the 'Decision on the manner of providing public services, including collection of mixed municipal waste and biodegradable municipal waste in the area of Čakovec', prescribes the details of the penalties. These can be issued in several cases, one of which is when the user of the waste collection service did not separate waste by waste stream, including the bio-waste stream. Penalties amount to 25HRK for each 10 litres of incorrectly sorted waste. When several service users share a waste bin (as in high-rise buildings, for example), if it cannot be determined which individual user bears the responsibility for contamination, then all service users who share the waste bin have to bear the financial consequences of the penalty.[32] However, the burden of proof is with the public service provider. Since penalties for individuals are present, a '2' is given for this instrument.

Dekanovec

Dekanovec also has legally-prescribed penalties for incorrect sorting of bio-waste, on a similar basis as Čakovec.[33] Bio-waste is one of the streams for which penalties can be incurred, and the penalties are determined on the basis of the price list of public services, relative to the amount of damage caused by the incorrect sorting. The penalty is prescribed to never exceed the minimum annual price of the waste collection service provided. [34] For these reasons, Dekanovec is given a '2' for this instrument.

Gospić

Gospić also has legally-prescribed penalties for incorrect sorting of waste, but these only relate to the placing of hazardous materials into residual waste bins. There is no mention of bio-waste or its sorting in Articles 81-83 on penalties in the 'Decision on the manner of providing public services, including collection of

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31 Čakovec Municipality (2017) <https://www.esavjetovanja.cakovec.hr/dokumenti/nacrti/Nacrt_PGO_Grada_Cakovca.pdf> Accessed 1 July 2023.

32 Čakovec Municipality (2017) <https://www.esavjetovanja.cakovec.hr/dokumenti/nacrti/Nacrt_PGO_Grada_Cakovca.pdf> Accessed 1 July 2023.

33 Municipality Dekanovec, 'Odluka o načinu prikupljanja mješanog komunalnog otpada i biorazgradivog komunalnog otpada' (Dekanovec Municipality Decision, December 2019) <https://www.dekanovec.hr/web/attachments/article/439/Odluka%20o%20na%C4%8Dinu%20pru%C5%BEanja%20javnih%20usluga%20prikupljanja%20otpada.pdf> Accessed 1 June 2023, Article 17.

34 Ibid.

mixed municipal waste and biodegradable municipal waste in Gospić'. As such, a '1' is given for this instrument, as there is a scheme for such penalties but they do not yet apply to bio-waste.

Lovinac

Lovinac has legally-prescribed penalties for incorrect sorting of waste, including for bio-waste. However, as discussed above no bio-waste is collected in Lovinac and there are no options for collection – either kerbside or at dropoff points. As such, it is not possible that these penalties are actually implemented in practice. However, since they do exist, Lovinac is given a '1' for this instrument, but the question will be explored in the empirical segment of this research.

Appendix 5
Presence of Law and Policy Tools Table

This table was the basis for the heat map shown in Chapter 7.. In order to make the heat map for all three institutional level (EU, Dutch and Croatia) the data had to be normalised (converted to percentages). The data in this table shows the original values on which those percentages were based

	Law and Policy Tools	EU (3)	NL (11)	CRO (11)
Production (Foodstuff)	T: Targets/requirements on use of CRMs	3	5	4
	FC: CAP, Greater competence sharing	0	0	0
	FC: CAP, Precision Farming (ex: nutrient stewardship)	1	2	1
	Taxes on (raw) materials and products	0	2	0
	Soft law agreements	0	2	0
Collection	T: Landfill targets	1	0	1
	MI: Landfill tax	1	2	4
	T: Mandatory separate collection (VFG)	0	2	5
	T: Collection Targets (Sludge)	1	1	0
	FC: Information	0	3	6
	FC: Kerbside collection (VFG)	0	4	3
	FC: Dropoff points (VFG)	0	4	3
	MI: Waste collection charges (VFG)	0	4	3
	MI: Industry subsidies	0	0	0
	P: Penalties for individuals	0	3	2
	T: Reporting	1	4	2
Treatment	T: Targets for recycling and preparation for reuse	2	3	0
	FC: Licensing of waste-to-energy facilities only for non-recyclable waste	0	0	0
	FC: Permitting framework	0	3	7
	QC: Min. treatment standards per waste stream	1	3	1
	FC: Exchange of information	1	3	5
	QC: Inspections	0	0	0
	QC: Additional requirements for ABPs	0	0	0
	QC: Quality criteria for compost and digestate	2	3	1
	QC: Monitoring of treatment figures	1	2	0
	MI: Industry subsidies 'recycling credit'	0	1	1
	P: Penalties	0	0	0
Products	QC: End-of-waste criteria	2	7	9
	T: Specific (separate) targets for reuse	0	0	0
	QC: Quality control for fertiliser products	2	3	2
	QC: QC for bio-based plastic products	1	1	1
	QC: CE marking	0	0	0
	QC: Other labelling	1	0	0
	FC: Extended producer responsibility	0	0	0

Crotian Summary

Oprez, Raskorak!

Zakonska sredstva poticanja kružnog prehrambenog sustava oporabom neobnovljivih resursa iz otpada

Mnogi suvremeni globalni ekološki problemi proizlaze iz prekomjernog korištenja prirodnih resursa. Ovo istraživanje razmatra prekomjerno korištenje resursa i nedovoljnu primjenu kružnog gospodarstva u poljoprivrednom i prehrambenom sektoru. Unatoč tome što su već dostupne biotehnološke metode za oporabu hranjivih, organskih tvari iz tokova otpada - mnoge od njih ne primjenjuju se u Europskoj uniji na način koji iskorištava njihov puni potencijal. Ovo istraživanje upozorava na raskorak u zakonskim odredbama i istražuje njegov utjecaj na kružno gospodarenje vrijednim organskim resursima iz biootpada (VFG) i mulja iz otpadnih voda u dvije države članice EU, Nizozemskoj i Hrvatskoj.

Koristeći interdisciplinarnu, komparativnu i empirijsku metodologiju, ova studija prvo iscrtava pravni raskorak i glavne prepreke na razini EU, na razini države i na razini lokalne samouprave (s objašnjenjem gdje i zašto se pojavljuju). Potom ukazuje na zakonodavne alate i alate javnih politika koji su potrebni da bi se uočene prepreke prevladale. Rezultati istraživanja su ukazali na potrebu: fokusiranja postrojenja za obradu (barem kratkoročno) na anaerobnu digestiju i kompostiranje; uravnoteženja količine zakonskih propisa i njihovog fokusa; revizije odnosa institucionalne moći u različitim fazama životnog ciklusa ovih resursa; i razrješenje sukoba različitih ciljeva javnog interesa. Studija završava s preporukama vezanim za jasnoću zakonskih odredbi, ravnomjerno zakonsko opterećenje tradicionalnih i kružnih sudionika, pozornost na zanemarene dijelove životnog ciklusa resursa i istovremenu potrebu za blagim usmjeravanjem, ali i obaveznim elementima zakonodavstva na razini Europske unije.

Dutch Summary

Let op de gaten!

Wetgevende middelen om een circulair voedselsysteem te stimuleren door het terugwinnen van niet-hernieuwbare grondstoffen uit afval

Veel wereldwijde milieuproblemen vinden hun oorsprong in de uitputting van natuurlijke grondstoffen. Dit onderzoek bestudeert de uitputting van grondstoffen en een gebrek aan circulariteit in de context van het agrarische voedselsysteem. Ondanks de beschikbaarheid van biotechnologische methoden in de EU voor het terugwinnen van voedingsstoffen en organisch materiaal uit afvalstromen, is de realiteit dat deze methoden nog niet volledig worden benut. Dit onderzoek identificeert de tekortkomingen in de wetgeving van twee EU-lidstaten (Nederland en Kroatië) en in EU-wetgeving zelf en analyseert hoe het circulaire beheer van waardevolle organische grondstoffen uit bio-afval (GFT) en rioolslib hierdoor wordt belemmerd.

Gebaseerd op een interdisciplinaire, rechtsvergelijkende en empirische methodologie, begint het onderzoek met het in kaart brengen van de beperkingen en obstakels in wetgeving en beleid op EU-, nationaal, regionaal en gemeentelijk niveau. De oorzaken voor deze beperkingen en obstakels worden eveneens geanalyseerd. Vervolgens worden wetgevings- en andere juridische en politieke instrumenten geïdentificeerd om deze obstakels te slechten. De onderzoeksbevindingen op dit punt zijn dat: (1) er op de korte termijn behoefte is aan verwerkingscentra gericht op anaërobe vergisting en compostering; (2) er een betere balans nodig is qua doelen (en dan vooral een grotere gerichtheid op duurzaamheidsdoelen), meer focus en ook meer balans in de hoeveelheid wetgeving (die zeer kan verschillen tussen de fases in de levenscyclus en ook van het type wetgeving); (3) een analyse van het verdeling van de (gewenste) verdeling van bevoegdheden tussen de EU en de lidstaten met betrekking tot de verschillende fases in de levenscyclus van grondstoffen; (4) een beter evenwicht mogelijk is tussen tegenstrijdige publieke belangen. Het onderzoek eindigt met aanbevelingen om meer juridische duidelijkheid te creëren ; de lasten voor traditionele en circulaire partijen beter af te wegen; meer aandacht te geven aan tot nu toe verwaarloosde onderdelen binnen de levenscyclus van grondstoffen; en de behoefte aan zowel 'softe' sturingsinstrumenten als verplichte samenstellingsvereisten op EU-niveau.