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Passing the baton: How intermediaries advance sustainability transitions in different phases

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ABSTRACT

Recently, increasing attention has been paid to *intermediaries*, actors connecting multiple other actors, in transition processes. Research has highlighted that intermediary actors (e.g. innovation funders, energy agencies, NGOs, membership organisations, or internet discussion forums) operate in many levels to advance transitions. We argue that intermediation, and the need for it, varies during the course of transition. Yet, little explicit insight exists on intermediation in different transition phases. We integrate existing conceptual models on transition dynamics and phases and a typology of transition intermediaries to examine how intermediaries advance transitions in different phases. We illustrate our conceptual insights through examples from car clubs, heat pumps and low-energy housing. We conclude that intermediation is paramount from predevelopment to stabilisation of a transition. Intermediary functions change from supporting experimentation and articulation of needs in predevelopment, to the aggregation of knowledge, pooling resources, network building and stronger institutional support and capacity building in acceleration.

1. Introduction

Recently, increasing attention has been paid to intermediaries, i.e. actors that connect multiple other actors, involved in sustainability transitions (e.g. Smith et al., 2016). An emerging body of literature on intermediaries in transitions exists, which aims to clarify inconsistencies regarding which actors can be regarded as intermediaries and which activities are relevant for intermediation (Gliedt et al., 2018). Previously, it has been highlighted that intermediary actors appear necessary and that they operate on many *levels* to advance transitions; building from grassroots and local action (Hargreaves and Hielscher, 2013; Barnes, 2018) to delegitimising existing institutional frameworks and lobbying for new ones (Smith et al., 2016). There is also a growing evidence of specific intermediaries playing crucial roles in certain *phases* of transition. For example, niche intermediaries have been important in the early stages of UK community energy (Smith et al., 2016), while in accelerating transitions, systemic intermediaries employ strategies to align various perspectives and activities, and prevent strategic games by others (van Lente et al., 2003).

We argue that studying intermediary action in different phases and levels of transition is important, because intermediary actions

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can be regarded as an essential contributor to explaining transition processes (e.g. Medd et al., 2012; Mignon and Bergek, 2016). Yet, existing literature shows little *explicit* insight on intermediation in phases and levels of transitions. Van Lente et al. (2011), as a rare example, have listed possible roles for *systemic intermediary* organisations in different phases. Building on van Lente et al. (2011), and taking stock of the most recent studies (e.g. Gliedt et al., 2018; Mignon and Kanda, 2018), we discuss the actions of different intermediary types (Kivimaa et al., 2018) in phases of transitions. We hypothesise that such intermediary actions and the need for them vary during the course of transitions. We draw on conceptual insights from previous literature to create a proposition of the activities of different types of transition intermediaries in different transition phases and levels. Furthermore, we present three empirical cases, based on previously published research, to illustrate the variation in intermediating transitions.

Effectively, we integrate existing conceptual models on transition dynamics (the multilevel perspective, MLP), transition phases and transition intermediaries to examine how intermediaries advance transitions in different phases. Although both phases and levels simplify complex transition dynamics, they are useful for paying explicit attention to and for clarifying the different functions intermediaries undertake, the configurations of intermediaries, and shifts in the type, position and importance of over the course of transitions.

Section 2 sets a background on intermediaries in transitions, the multilevel perspective (MLP) and phases of transitions. Section 3 builds an integrated framework regarding intermediaries in phases and levels of transitions, and Section 4 illustrates this, drawing on examples from the United Kingdom low-energy homes, Finnish heat pumps and Dutch automobility. Section 5 discusses and Section 6 concludes.

2. Conceptual background

2.1. Defining intermediaries in transitions

The literature on intermediaries in transitions originated in the early 2000s, Van Lente et al. (2003) making a case for 'systemic intermediaries' in long-term, complex processes including transitions to sustainability. Later, Geels and Deuten (2006) described the dedicated aggregation activities that various intermediaries conduct to make connections between local practices and global technological development. Despite these early openings, intermediaries have only more recently began to gain explicit attention in the sustainability transitions literature (Gliedt et al., 2018; Mignon and Kanda, 2018).

Thus far, a clear definition for 'transition intermediary' actors has been lacking, and the literature has portrayed a diversity of actors and actions as intermediaries and intermediation in the context of sustainability transitions. To address this diversity, we define transition intermediaries as "*actors and platforms that positively influence sustainability transition processes by linking actors and activities, and their related skills and resources, or by connecting transition visions and demands of networks of actors with existing regimes in order to create momentum for socio-technical system change, to create new collaborations within and across niche technologies, ideas and markets, and to disrupt dominant unsustainable socio-technical configurations*" (Kivimaa et al., 2018: 11).

Theoretically, the understanding of intermediaries in transitions has drawn from multiple origins, including empirical observations of their roles in transition processes (e.g. Geels and Deuten, 2006; Hodson and Marvin, 2009, 2010), the literature on innovation intermediaries (based on management and science and technology studies; e.g. Howells, 2006; Stewart and Hyysalo, 2008), and the literature on systems of innovation (Lundvall, 1992; Nelson, 1993; Edquist, 1997). In transition studies, most attention has been paid to intermediaries in niche development (e.g. Geels and Deuten, 2006; Hargreaves and Hielscher, 2013), while intermediaries have been rather neglected in the strand of technological innovation systems (e.g. Lukkarinen et al., 2018).

Depending on the empirical context, the literature describes a range of actors and platforms as intermediaries, including (but not limited to) governmental and institutional agencies such as innovation funders and energy agencies (Polzin et al., 2016; Barrie et al., 2017), city-level organisations (Hodson et al., 2013; Kampelmann et al., 2016), community energy actors (Hargreaves and Hielscher, 2013; Martiskainen, 2017), dedicated networks (Ingram, 2015; Lukkarinen et al., 2018), environmental NGOs (Rohracher, 2009), architects (Fischer and Guy, 2009), and internet discussion forums (Hyysalo et al., 2013, 2018). Moreover, intermediaries that play a role in advancing new technologies as inputs to sustainability transitions, include science parks, consultants, technology transfer agencies and local actors supporting technology use (Howells, 2006). Part of all these organisations have a 'fixed' or 'prescribed' contribution as intermediaries due to their organisational form or identity (i.e. the type of organisation they are). However, sometimes, intermediation is more implicit and rather speaks from the functions and activities; defining who is an intermediary in transitions. Thus, the label of 'intermediary' can be a temporary and fluctuating quality in actors and platforms, especially regarding specific transition efforts and sub-processes. Different intermediaries have complementary and synergistic roles and act in 'ecologies of intermediaries' (Stewart and Hyysalo, 2008; Klerkx and Aarts, 2013; Mignon and Kanda, 2018).

Intermediaries carry out certain functions in innovation and transitions processes, including articulation of expectations, demands and visions; creating and brokering networks; exchange of knowledge and support of learning processes; innovation process management (e.g. mediation, resource procurement); translation between different actors, interests and contexts; capacity building, including the creation of required knowledge; institutional support (e.g. advocacy and lobbying support); and configuration of local technological assemblages (Van Lente et al., 2003; Stewart and Hyysalo, 2008; Klerkx and Leeuwis, 2009; Kilelu et al., 2011). Each function requires different types of intermediation activities. For example, creating networks involves the identification of suitable participants and motivating them to join the network. Innovation process management involves managing the discussions within the network, sometimes taking the role of a neutral arbitrator or mediator. Support for learning processes entails collecting information or knowledge of pilots, aggregating and modifying that knowledge, and communicating and translating that to different stakeholders.

Based on these functions and a systematic review of transitions literature, we have elsewhere illustrated five categories of intermediaries playing a role in transitions (Kivimaa et al., 2018): systemic intermediaries, regime-based transition intermediaries, niche intermediaries, process intermediaries and user intermediaries (Table 1). This differentiation draws from the goals of

Table 1
Transition intermediary types (Kivimaa et al., 2018).

Category	Context/ level of action	Emergence	Goal of inter-mediation	Normative position		Examples
				Position vis-à-vis niche	Neutrality/ interest	
Systemic intermediary	Intermediating on system level between multiple actors & interests	Typically established to intermediate	Pursues given (sustainability) goals on a system level; ambitiousness towards disruption to existing system	Outsider to specific niches, creating space for multiple, alternative niches	Typically regarded as a position of neutral, unbiased facilitator and broker, despite having an interest in stimulating transitions	Innovation Network Rural Areas and Agricultural Systems, Netherlands; SITRA, Finnish Independence Fund; Industrial Biotechnology Innovation Centre (IBioIC), Scotland
Regime-based transition intermediary	Intermediating on system level between multiple actors, within mandate given by dominant regime actors	Existing actor subsuming intermediary roles; or established by dominant regime actors to intermediate for transition)	Pursues given (sustainability) goals through typically more incremental solutions or political aims	Outsider to specific niches, creating space for multiple, alternative niches	Regarded as a player in the dominant system but pursuing or empowered for change	Motiva, Finland; Forest Industries' Water and Air Pollution Research Foundation, Sweden; Greater Manchester Climate Change Agency; Religious congregations (sometimes)
Niche (or grassroots) intermediary	Intermediating between local projects, and/or higher level of aggregation	Often emerging to intermediate when a niche develops	Pursues given (sustainability) goals and solutions from a perspective of a given niche	Insider to a specific niche	Regarded as player advancing a particular niche	Community energy initiatives, England; Wave Energy Association WAVEC, Portugal; Living Community Challenge, Canada/US; Standardisation committees for new technology
Process intermediary	Intermediating within experimental projects or specific processes contributing to transitions	Typically established/ employed to intermediate day-to-day action in transition projects or processes	Implementing context-specific priorities, informed by broader transition trajectories	Typically outsider to specific niche	Regarded as a neutral, unbiased 'networker' that does not have specific 'agenda' in the process	Sustainability consultant; Project manager ; Architect
User intermediary	Intermediating between technology (provided) and use, and/or niche technology and dominant configuration	Emerges from amidst users and consumers	Acts as facilitator, representative, or broker of end-use or end-users.	Insider or outsider to specific niche	Leans towards user interests (in some cases even as activists)	Internet discussion forum for heat pumps; Car user clubs (in early phases); Advocacy groups; Building manager (sometimes)

intermediation, the emergence of the intermediary actor, and the context in which the intermediary operates. We will below utilise this typology to address intermediation in different transition levels and phases.

2.2. Levels of analysis for understanding sustainability transitions: niches and regimes

The MLP describes transformative change in socio-technical systems to occur through interplay between three levels, including micro-level spaces in which radical innovations emerge (so called 'niches'), relatively stable and shared technologies, practices and institutions ('regimes'), and slow-moving developments in the exogenous environment ('landscape') (Rip and Kemp, 1998; Geels, 2005). The interaction between niches and regimes has been studied using different concepts (Ingram, 2015). For example, Smith (2007) looked at *translation* between niches and regimes as the dialectic development between niche action and regime response. Recent studies have focused on micro-level processes and explored agency in transitions-in-the-making, studying the actions that actors employ to overcome barriers imposed by incumbent institutional structures in regimes (Farla et al., 2012; Fuenfschilling and Truffer, 2013). Here intermediaries between niches and regimes have been found crucial (Smink et al., 2015).

The interface between niches and regimes is characterised by framing struggles and different storylines and logics (Smink et al., 2015; Rosenbloom et al., 2016). Niche and regime actors interpret the need for transitions and the direction of change differently. In such struggles, intermediation may be relevant not only in connecting the niche and regime storylines (Hermans et al., 2016), but also in negotiating between different positions of actors within a niche or within a regime in processes of demand and vision articulation. At the niche-regime interface, intermediaries link niche actors with regime structures through network brokering and innovation process management, aid in negotiating change by assisting in the building of alliances, and bring in supporters from within the regime (Elzen et al., 2012; Hargreaves and Hielscher, 2013; Ingram, 2015; Smink et al., 2015; Hess, 2016).

The activities of transition intermediaries go beyond the facilitation of established niche-networks by brokering relationships that aim at creating institutional spaces (e.g. transition arenas, urban living labs) to support niche innovation. On the basis of such innovations, intermediaries articulate expectations and visions for a transformed society. Moreover, intermediaries bridge between distinct actors through translation: consumer preferences are translated towards technology developers, citizen demands towards the government to inform policies, and business knowledge needs towards academia to inform research agendas.

2.3. Phases of sustainability transitions

Sustainability transitions have been described as complex and long-term processes (e.g. Geels, 2011), the whole transformation process typically taking decades. The models and concepts used to study transitions, such as the MLP and transition phases, simplify the analyses of complex, large-scale structural transformations (Smith et al., 2005), while providing a "useful overall plot" (Geels, 2011). Such a plot can be used to show specific transition patterns, such as hype-disappointment cycles or niche-accumulation patterns play out in shorter time periods (Geels, 2005, 2011). Plotting phenomena and patterns is a balancing act between simplifying transition dynamics to tease out lessons and embracing the complexity (Sorrell, 2018: 1280). Here, we provide simplicity to examining intermediary dynamics during transitions, utilising the 'phases approach', while also paying due attention to the complexity of intermediary types, functions and ecologies that contribute to how transitions evolve. We explicitly focus on intermediation in phases of transitions, drawing on the categories proposed by Rotmans et al. (2001) but simplifying them into three phases as in Kanger and Schot (2016): pre-development, acceleration and stabilisation. For levels, we refer to the notions of niches and regimes (Rip and Kemp, 1998; Geels, 2005).

The *pre-development and exploration phase* is described as a dynamic equilibrium, where the status quo does not visibly change (Rotmans et al., 2001) but experimentation takes place (Safarzynska et al., 2012). Van Lente et al. (2011) see this phase as a combination, and conflict, between eagerness to find out what is possible (articulation of societal needs) and reluctance to change existing configurations. In this context, experimentation, typically defined as small-scale and temporary exploratory action (Kivimaa et al., 2017), can relatively easily take place even in change-resistant sociotechnical regimes. Niche technologies are not yet perceived as a threat by regime actors (Kanger and Schot, 2016).

In the *acceleration and embedding phase*, novel solutions, niches, start to build up (Safarzynska et al., 2012). Niche development moves from experimentation to other forms of nurturing and shielding niches (Smith and Raven, 2012), and the strategic management of and agenda building around niches takes place. In this phase '*niches expand, attract more users, and become mainstream markets starting to compete with the incumbent regime*' (Kanger and Schot, 2016: 600). Structural changes become visible through an accumulation of socio-cultural, economic, ecological and institutional changes, and collective learning and increasing returns take place (Rotmans et al., 2001; Safarzynska et al., 2012).

The *stabilisation phase* implies a decreasing speed of social change when a new dynamic equilibrium is reached (Rotmans et al., 2001) and '*a former niche has established itself as a new* regime' (Kanger and Schot, 2016: 600). Incremental change occurs to benefit from economies of scale. The cycle starts anew as experimentation in novel solutions commences again (Safarzynska et al., 2012). In reality, when different but connected sociotechnical systems change at different speeds, it may be difficult to know when stabilisation is reached. Further, niche acceleration does not always lead to overturning the incumbent regime, and may instead backlash or lock-in as a niche (Loorbach et al., 2017; Kivimaa and Martiskainen, 2018).

The MLP and transition phases' literatures are interconnected, although this link has remained mostly implicit. While the MLP literature has been less specific about phases of transition, Geels (2005) emphasised early phases being characterised by uncertainty and 'interpretive flexibility' around radical innovations. Safarzynska et al. (2012) note that the notion of a multiphase transition puts emphasis on the timing of intervention in steering transitions. We interpret this to mean that the (required) activities, agency and normative position of intermediaries change in the different phases.

By assuming niche development as the starting point of transitions, the model of transition phases does not take into account other types of transition pathways (cf. Geels and Schot, 2007; Geels et al., 2016) in which change originates from landscape or regime level inducements. As such, it underplays the process of destabilisation (cf. Turnheim and Geels, 2012) that may either follow the acceleration and embedding of niches (acknowledged in the model), or precede it in cases where external shocks or radical innovations promoted by incumbent firms disrupt the system (ignored in the model) and pave the way for an era of niche pre-development or acceleration.

Regime destabilisation has been defined as processes that disrupt incumbent (industrial) regimes through weakening reproduction of core regime elements, including radical policy reforms and deliberate replacement of incumbents (Turnheim and Geels, 2012). Kivimaa and Kern (2016) specified this as significant changes in regime rules, removing support for non-sustainable technologies, changing network patterns and introduction of new key regime actors. We take destabilisation into account in our conceptualisation of transition phases to occur simultaneously with, or before or after, niche specific processes of exploration and embedding.

3. Conceptual framework for intermediation and intermediaries in phases of transitions

By integrating three conceptual models (transition phases, the MLP and transition intermediaries), we argue that functions and activities of intermediaries can be conceptually differentiated based on their level and phase of operation. With respect to levels, they can, for example, pursue activities within emerging niches; work on destabilising and restabilising regimes; or translating or forecasting landscape developments. They can also pursue intermediating roles that further the transition between a niche and a regime, or between different regimes and regime-landscape relation. This differentiation is important from an analytical perspective and in considering what the agency and roles of intermediaries are in governing transitions.

Due to lack of previous literature on regime-landscape and landscape-level intermediation, we focus our conceptual elaboration on niche and regime levels. To connect the range of perspectives on intermediaries offered in previous literature with phases of transitions, we operationalised the phases in as much detail as possible. For this, we drew from the literature on phases of transitions (Rotmans et al., 2001; Safarzynska et al., 2012; van Lente et al., 2011) but simplified from four to three phases as in Kanger and Schot (2016). The operationalisation took into account that most articles were not specific about the phases they address, which required our interpretation and iteration. In Table 2, we propose specific functions and activities carried out by the five types of transition intermediaries in different phases and on different levels. Sections 3.1-3.4 elaborate on the types, functions and activities of intermediaries belonging to each transition phase, thus, explaining Table 2.

3.1. Pre-development and exploration

In the pre-development phase, experimentation and exploration are important, making early *niche intermediaries* vital. They can operate both at the grassroots level, having an important role in initiating and enabling pilots and experiments, and on a broader niche level, connecting experiments and pilots, comparing and aggregating learning, and enabling new types of networks to contribute to novel vision building (see e.g. Geels and Deuten, 2006).

For Portuguese wave energy, "*the early emergence of [niche] intermediary actors and formalization of arenas for debate favoured the conduction of field-level aggregation activities*" that guided the niche trajectory and articulated "*a compelling vision of future benefits*" (Fontes et al., 2016). While the articulation of visions, networking and learning are imperative, there is less need for translation, capacity building and institutional support in pre-development, because the direction is unknown and incumbents' resistance is low.

Grassroots organisations are a specific sub-type of niche intermediaries. They work bottom up to develop novel ideas and engage in a range of niche-specific experiments. Such grassroots intermediation can occur before an explicit niche has formed, or exist at most at local scale (Kivimaa et al., 2018). This has been shown in the case of UK community energy initiatives (Hargreaves et al., 2013; Martiskainen, 2017). In pre-development, grassroots intermediaries coordinate local projects existing in spaces where 'the rules are different' from (and at times opposite to) the mainstream (Hargreaves et al., 2013), voicing expectations and engaging in learning activities (Martiskainen, 2017) and creating reliable technological devices and configurations (De Vries et al., 2016). Also, *user intermediaries* without explicit transition agendas can form initial knowledge sharing networks in local contexts and become involved in innovating their own equipment and sharing their insights among peers (Hyysalo et al., 2013).

Local experimental projects also benefit from *process intermediaries* that have an important role in facilitating on-the-ground projects, and occasionally disseminating projects' learning and visions to others (Barnes, 2018; Martiskainen and Kivimaa, 2018). At the niche-regime interface, process intermediaries translate context-specific regime priorities into the design and implementation of local projects (Hodson et al., 2013).

Systemic intermediaries, in pre-development, can create institutional and social space for alternative technologies, models and social constructs to emerge, through demand articulation and institutional support. Intermediaries have been described to open up spaces in local, policy, market or social contexts (Hargreaves et al., 2013) to a diversity of options and activities rather than a single technology, successful approach or strategy (van Lente et al., 2003). Furthermore, systemic intermediaries act as catalysts of innovation and initiate niche experiments, thus, engaging in innovation process management (Klerkx and Leeuwis, 2009; Kivimaa, 2014).

Regime-based transition intermediaries are likely to have only a small role in pre-development. Regime-based R&D and innovation funders can help to find new sources of funding for basic and applied research (Polzin et al., 2016), through supporting network building and innovation process management.

Table 2
Summary of classification of innovation intermediaries' functions and activities, differentiated by level, type and phase.

Phase of transition	Destabilisation (can precede or follow acceleration)		
	Systemic intermediaries decreasing public legitimacy for and endogenous commitment to an existing regime; destructing existing networks, markets and institutions; translating new forms of regulation to practice. *Niche intermediaries* aiming for destabilisation (coupled with functions for vision articulation, new network formation, capacity building and institutional support). *Regime-based transition intermediaries* translating destabilising policies into practice or making sense of a complex and changing policy environment to niche innovators.		
	Pre-development & exploration	Acceleration & embedding	Stabilisation
Niche level intermediation	*Niche, user, process & systemic intermediaries* promoting experimentation & coordinating projects. *Niche intermediaries* forming networks, sharing best practices and creating reliability for new technology. *User intermediaries* forming initial knowledge sharing networks; configuring systems and uses, qualifying claims by producers and resellers; articulating demand for niche producers.	*Niche intermediaries* aggregating knowledge, guiding local experiments, replicating projects and pooling resources. *Process intermediaries* facilitating embedding of niches (that they are outsiders to) to particular contexts of application *User intermediaries* fill in information missing in the emerging markets and in technology use and maintenance.	*Niche, user, process and systemic* intermediaries promoting experimentation & coordinating projects.
Niche-regime intermediation	*Niche intermediaries* articulating early expectations. *Process intermediaries* connecting context-specific regime priorities and local projects. *Regime-based & systemic intermediaries* finding and directing funding for niche R&D activities.	*Niche intermediaries* supporting niche embedding (aiming to increase size and stability) and developing shared institutional infrastructure (e.g. standard bodies). *Regime-based transition intermediaries* supporting niche build up through practical action & forming networks with other transition intermediaries; engaging in market creation. *Systemic intermediaries* aligning different perspectives and preventing strategic games; engaging in market creation and identification / evaluation of promising niches. *User intermediaries* facilitating technology adoption and reconfiguration by users	*Niche intermediaries* seizing to exist / changing roles. *Process intermediaries* connecting context-specific local priorities and local projects *Regime & systemic intermediaries* finding and directing funding for niche R&D activities.
Regime level intermediation	*Systemic intermediaries* articulating societal needs for change; making a variety of technological options more visible; creating political and institutional space.	*Systemic intermediaries* maintaining/ strengthening political and institutional space. *Regime intermediaries* raising public awareness and creating legitimacy for the new pathway. *Niche intermediaries* lobbying for visibility and resources in political strategy making	New *regime intermediaries* emerging to fill institutional gaps, in response to new governance modes or to market restructuring. *Niche intermediaries* transforming into new regime intermediaries. *Systemic intermediaries* looking out needs for change

3.2. Acceleration and embedding

During acceleration and embedding, visioning and network activities become more explicit, alongside new technologies accumulating and diffusing. Actors, including regime-level policymakers, begin to set transition goals. In the literature, acceleration connects to the idea of strategic niche management (e.g.Hargreaves and Hielscher, 2013).

In the beginning of acceleration, local experiments and the learning they generate become more aggregated, gradually forming a niche on a regional, national or global level (Geels and Deuten, 2006; Hargreaves et al., 2013; Seyfang et al., 2014; Fontes et al., 2016). In these aggregation processes, *niche intermediaries* are vital, both within the niche and in the niche-regime interface. Niche intermediaries improve knowledge flows between local experiments and the niche, increasing the production and circulation of knowledge that is intended for the field as a whole (Geels and Deuten, 2006). In addition, they can develop shared institutional infrastructure, for example, supporting the creation of new standards and rules (Smith et al., 2016).

Grassroots intermediaries may not have the capacity or ambition to be central actors in acceleration. Not all grassroots innovations wish to grow and diffuse, and may exist without major transition visions (Hargreaves et al., 2013). They may seek to pool and connect with other grassroots initiatives to form broader networks, as has happened in the organic food movement (Durrant, 2014) and in community energy (Alarcon Ferrari and Chartier, 2017). This may mean that other niche intermediaries or user intermediaries come to supplant some functions grassroots intermediaries previously played (Hyysalo et al., 2018).

As much experimentation still takes place, *process intermediaries* act similarly as in pre-development. What is different is that the context-specific regime priorities (cf. Hodson et al., 2013) may have changed through the increased diffusion of new solutions and,

thus, process intermediaries need to adjust to them, through functions such as innovation process management and translation, supporting this renegotiation process. Moreover, a larger number of actors (such as architects, planning officials or consultants) may expand their expertise to fit with the transition (cf. Martiskainen and Kivimaa, 2018), effectively becoming process intermediaries.

Regime-based transition intermediaries take a more visible role during acceleration, beginning practical action supporting niches (e.g. contributing to vision formation, knowledge exchange and learning support, innovation process management, and translating between the regime interests and alternative niches). They also form networks with other transition intermediaries (Kivimaa and Martiskainen, 2018). The government may even establish new intermediary organisations with a transition orientation. For example, the UK government founded the Sustainable Buildings Task Group, which resulted in a draft Code for Sustainable Homes to encourage practice that goes beyond the minimum standards for energy efficiency in the building regulations (Pickvance, 2009). This task group was a prime example of a regime-based transition intermediary forming a core of a network of other intermediaries. In addition, some social housing associations have become active regime-based transition intermediaries in supporting a transition towards more sustainable buildings through piloting new solutions (contributing to vision formation) (e.g.Castán Broto, 2012).

Systemic intermediaries also become more important, as they engage in market creation for alternative niches (e.g. through constructing broader future visions and institutional support) and evaluate potentially promising niches. They may also try to change the regime from within by articulating societal needs for change, and create new political and institutional space. For example, the Finnish Independence Fund Sitra has systematically intermediated to change building regulations to allow for innovation in low-energy buildings to diffuse (Kivimaa, 2014).

User intermediaries are active in co-constructing the market and its related institutions, including the formation of market segments and transactions (Moors et al., 2017). User intermediaries also contribute to facilitating early user practices and configuring their technical systems. User intermediaries further link users' needs and solution information to resellers and manufacturers, thus contributing to demand articulation regarding new settings and new uses (Heiskanen et al., 2014; Hyysalo et al., 2018).

Later in the acceleration phase, *niche intermediaries* try to lobby for recognition and resources in political strategies for accelerating the niche (White and Stirling, 2015). If acceleration is successful, some niche intermediaries gradually become new regime intermediaries (Orstavik, 2014), and others cease to exist.

Intermediaries become less visible as technology matures; a relevant function for *regime-based transition intermediaries* and *process intermediaries* during commercialisation and diffusion being the mitigation of uncertainty and risk between firms or research institutes and potential funders (Polzin et al., 2016). This can be addressed by effective innovation process management, translation between the parties concerned, and institutional support.

User intermediaries continue to be involved in increasing the size and stability of the accelerating niche and may act as watchdogs to the expanding market and new market entrants, providing relatively unbiased information on the transition technologies and producer offerings on the market (Kanger and Schot, 2016; Hyysalo et al., 2018).

Systemic intermediaries help in articulating, negotiating and aligning the various perspectives to be more compatible with each other, advancing standardisation and preventing strategic games (van Lente et al., 2003, 2011; Rohracher, 2009). However, in some cases systemic intermediaries may have stopped working on the transition in question and moved to new challenges (Kivimaa, 2014).

Regime-based transition intermediaries, such as government or local authority intermediary agencies, can raise public awareness and create legitimacy for the new pathway. In stretch-and-transform acceleration (Smith and Raven, 2012), new regime building and negotiation are likely to be prevalent activities, while in fit-and-conform acceleration, intermediaries may aim to raise public awareness rather than let users actively influence the transition (Mattes et al., 2015).

The role of *process intermediaries* has changed from supporting experimental projects to facilitating the embedding of niches to particular contexts of application, through means of translation. This is particularly important in those transitions, where a solution is not an easily diffused technology applicable in multiple contexts, but rather requires context-specific fitting to operate optimally (zero-energy buildings being a case in point).

3.3. Stabilisation

Stabilisation means returning in many respects to pre-development, where the cycle of supporting emerging niches starts anew in light of new societal challenges. Regarding the past transition, some niche intermediaries cease to exist as they are no longer necessary. Other intermediaries can continue to seize novel business opportunities in a newly stabilised regime, simultaneously shaping or transforming the regime (Rohracher, 2009) to the pursuit of their own and common objectives. Also new regime intermediaries may emerge to fill institutional voids and as reactions to restructured markets or new governance modes (e.g. Moss, 2009). Rather little analysis exists on what happens to intermediaries in a newly stabilised regime.

Prior to the stabilisation phase of a new regime, the previous regime must have gone through destabilisation. Destabilisation as a process can precede or run in parallel to phases of pre-development and acceleration, being particularly closely related to the latter. It departs from the perspective of an extant regime that is shifting, stimulated by niche developments or influenced by landscape changes. Change can also originate from within the regime (see work on transition pathways by Geels and Schot, 2007), where regime actors may also act as intermediaries (Späth et al., 2016), with genuine or disguised motives towards transitions (Pel, 2016). The timing of destabilisation vis-à-vis the phases influences the kind of intermediaries that emerge and take action.

Systemic intermediaries (e.g. van Lente et al., 2003; Klerkx and Leeuwis, 2009) can be seen as important actors in destabilisation. They may aim to disrupt existing institutional frameworks or markets (Nielsen, 2016) or destruct existing networks, and set-up new networks that disturb existing structures (Klerkx and Leeuwis, 2009; Hodson and Marvin, 2009). Thus, they can simultaneously facilitate a broader niche accelerating and destabilise the regime from within. Systemic intermediaries face other kinds of

intermediaries as a counterforce that may "*thwart rather than promote potentially useful but disruptive innovations*" (Orstavik, 2014). *Niche intermediaries* play a role in destabilisation for their own niche's benefit.

Destabilisation generates demand for new forms of intermediation not previously required or recognised (Moss, 2009; Rohracher, 2009). For example, *regime-based transition intermediaries* may be needed to translate new forms of regulation into practice (Fischer and Guy, 2009; Moss, 2009) or make sense of a complex, changing policy environment to niche innovators. Moss (2009) and Rohracher (2009) argue for the emergence of intermediaries (e.g. NGOs, advisory groups, information campaigns) that liaise between producers/suppliers and consumers in the changing market context, i.e. new *user* and *regime-based intermediaries*.

4. Illustrative examples from Dutch automobility, Finnish heat pumps, and UK low-energy homes

Here, we will draw on three illustrative cases (Table 3) to complement our conceptual analysis above. The illustrations are based on previously published research by the authors (Kanger and Schot, 2016; Hyysalo et al., 2018; Kivimaa and Martiskainen, 2018), have emphasis on different phases of transitions, cover different geographical and innovation contexts, and illustrate different aspects on intermediation in transitions. The UK low-energy homes and Finnish heat pump examples address current attempts to transition towards a sustainable energy system. The former shows how a significant number of public and civil society intermediaries act in a transition, and how the whole 'ecology' of these intermediaries change over time. The latter shows how, initially, heat pumps did not diffuse due to lack of intermediation but later enabled take-off. The Dutch automobility demonstrates how one intermediary, the Dutch Tourist Organisation, can be crucially important for all stages of a transition.

Table 3
Illustrative cases.

Niche/transition	Country	Time period	Phases covered	Intermediaries covered
Automobility	Netherlands	1896-1970	All phases	Focus on a single central actor
Heat pumps	Finland	1980-2018	Pre-development & acceleration	Growing diversity (> 20) and stabilization
Low-energy homes	United Kingdom	1970-2016	Pre-development & acceleration	Significant diversity (> 70)

4.1. Dutch automobility: the intermediary role of the Dutch Tourist Organization (ANWB) in transition

4.1.1. Pre-development (1898–1910)

This history of the automobile in the Netherlands is not a simple diffusion process of cars but a process of developing new user practices, institutions, regulations, production methods and automobiles. Intermediary activities were a central plank in this process, becoming concentrated around one actor: the Dutch Tourist Organization (ANWB).[1]

Early car use was associated with racing, generating much publicity. The first car race was organised in 1898 by the newly founded Dutch Automobile Club (Nederlandse Automobiel Club, NAC, later the Royal KNAC), consisting of car users and importers (Mom, 2019). This club functioned as a *niche intermediary* forming networks, promoting experimentation and creating early expectations through racing, articulating the car as an adventure machine, a plaything for the rich. This messaged the exciting masculine combination of fear and pleasure in the experience of speed and, also, an opportunity to explore landscape traveling without a fixed schedule as with trains or trams (Mom, 2019). Other supportive intermediaries were absent in pre-development.

4.1.2. Acceleration (1910–1940)

When the niche development progressed from pre-development to acceleration, a new actor moved into the automobile domain and became a significant *niche intermediary*: the Dutch Tourist Organisation ANWB, originally promoting cycling. ANWB's vision was that the car should be turned into a utilitarian machine, addressing the needs of doctors, salespersons and shop owners. The organisation began to articulate demand for a new type of automobile.

Already in 1907, the editor-in-chief of *De Kampioen*, ANWB's membership magazine, complained in an editorial that the automobile had *"grown into a machine that competes with express trains in speed" (*Meijer, 1907:2). He continued, that this was regrettable, because many people travelling long distances would be enthusiastic buyers of a reliable automobile with an engine to give a speed of 15–20 kilometres per hour (Meijer, 1907).

Later, becoming a crossover between a *niche* and a *user intermediary*, ANWB helped formulate standards and translate user demands. The utilitarian affordable and reliable automobile, which ANWB called for, became more prominent after the First World War with the arrival of Ford's Model T.

ANWB shaped the competition with public transportation, promoting the view that the future was for the car, since it was a multifunctional machine that could be used for many purposes. ANWB aimed at confronting the competitor, playing a strategic game.

In 1927, ANWB was one of the first organisations to forecast the future diffusion of automobiles. In *De Kampioen* (4 March 1927, 193–194), ANWB pointed out that, at that moment, 2.5 million bicycles were in use and that a comparable number of cars was to be expected by 1950. The envisioned wider diffusion meant that car drivers had to be educated to participate in daily traffic, e.g.,

[1] This case study draws extensively on Mom et al. (2008).

passing other cars, taking curves, and braking while simultaneously signalling with one's hand. Therefore, ANWB not only acted as representative of users but also tried to educate and discipline them, building capacity. Concerns about car accidents and traffic casualties (often widely expressed in newspapers) were important motivations for these educational efforts.

A national infrastructure was gradually created to support car and bus use. Until 1920, most roads were local or regional, linking different cities. In the 1920s, a powerful road lobby emerged, advocating for new kinds of road, highways, which were restricted to motor vehicles only. Members of this road lobby were the Royal Institute of Engineers, ANWB, (K)NAC and construction companies. They also lobbied for national infrastructure to accommodate the expected car growth. ANWB developed a new discourse, presenting cars as an economic and social necessity. These forecasts and surrounding discourse underpinned the need for new roads. Rijkswaterstaat (RWS), the engineering and building department of the Ministry of Traffic and Transport, supported this idea and developed the first National Road Plan (1927), which the government accepted. This plan envisaged a national network of 2800 km of primary roads, involving both new roads and upgrading existing roads. The government plan also entailed the creation of a Road Fund to collect and coordinate money through the Road Tax Law.

The creation of new road infrastructures, requiring huge investments (only partly paid through car taxation), led to questions about relationships with existing rail infrastructures. In the 1930s, this resulted in a 'coordination crisis', which was related to infrastructure junctures and to investment decisions. ANWB, and other car proponents, aiming to further destabilise the past transport regime, portrayed rail as technology of the past, often needing subsidies, and cars as the future. ANWB began articulating a new vision of the automobile user, aimed at the 'nuclear family'. In 1935, the *Autokampioen* (14 September, p. 1253–1255) expressed a desire for "*a people's car (…) that due to its price and economy will enable each family … to travel by road … The motorist of our age is … the father of a family who takes his wife into the country to be free in heath lands and grasslands, to beaches and lakes*".

4.1.3. Stabilisation (1945–1970)

After World War II, the people's car arrived, and the automobile lost the exclusively middleclass character. ANWB turned into a regime intermediary promoting and facilitating car use for everyone. To convince car buyers, ANWB campaigned for the rationality of car purchases. It promoted a new do-it-yourself culture, especially amongst lower middle class and working class users, while it recognised that not everyone wanted to repair their own car and carry the required tools along. Hence, ANWB created a new maintenance-technical infrastructure. In 1946, ANWB founded its nationwide road service organisation, *Wegenwacht*, especially tailored at roadside breakdowns.

Social-recreational car traffic increased substantially during 1963–1993, becoming one of the most important functional categories in the late 20th century. The car was increasingly used for visits to relatives and friends, weekend outings, and holiday trips. ANWB's vision of the car as a multi-functional and universal machine to be used for all transport needs of the entire population had come true, with ANWB as its guardian.

4.2. Finnish heat pumps: Evolution of an ecology of intermediaries from acceleration to the brink of stabilisation

4.2.1. Pre-development (1980–1995)

First heat pumps entered Finland from Central Europe and Sweden in the early 1980s in response to the 1970s oil crises. The early heat pumps used horizontal collecting fields on the ground or water, and were introduced and endorsed by researchers, interested companies and forerunner citizens. A handful of companies introduced heat pumps to their offerings and around 2000 were installed during the 1980s. Market development was hindered by technical shortcomings, uncertain payback times, maintenance problems and adverse appraisals from energy field experts and energy incumbents in the media. There was a lack of coordination, knowledge sharing and common voice in the media and towards customers, due to the spokespeople for heat pumps being scattered and weak (Lauttamäki, 2018). Specific intermediaries advocating heat pumps were absent.

4.2.2. Acceleration (1995–2018)

The continued proliferation of heat pumps in the neighbouring country Sweden and the development of vertical borehole techniques led to a second wave of ground source heat pump (GSHP) installations in the mid-1990s. This time two *niche intermediaries* were established to avoid the early problems: a heat pump entrepreneur and a heat pump researcher established the Finnish Heat Pump Association (SULPU), with support from the Finnish Energy Efficiency Agency (Heiskanen et al., 2011), while other involved companies set the Finnish Bore-well Association. They were established to bring incumbent and new heat pump companies together to create a shared, believable channel for endorsing heat pumps to public authorities and the media (Lauttamäki, 2018). Particularly SULPU mediated information about heat pumps to media, planners, policy makers, and energy experts, i.e. it was involved in articulating a vision and translating knowledge. It further shared best practices, educated its member companies and policed the quality of installations, helping to raise the reliability of the field (Lauttamäki, 2018).

By early 2000s, Finland had about 30,000 heat pumps through linear growth in ground-source heat pumps (GSHPs) and a surge in the uptake of air-source heat pumps (ASHP) from 2002. Whereas incumbent experts continued to express doubts about the suitability of ASHPs to the cold climate, ASHP's low consumer price ranging from hundreds to few thousands of euros motivated purchases. An increasing variation in makes and models became available through both dedicated small installation companies and larger retail stores (Heiskanen et al., 2011, 2014).

Early acceleration was accompanied by several actors playing intermediary roles, while not being specific niche advocates. Local energy advisors and the National Energy Efficiency Agency, as *regime-based transition intermediaries*, included heat pumps to their lists of recommendations. Research institutes and polytechnics, also as *regime-based transition intermediaries*, ran and published evaluations

and cumulated expertise on heat pumps. Technical and professional press, and mass media relayed key information about the new technology to the public. In addition, the growing number of users acted as *user intermediaries* to their friends and neighbours, articulating the benefits of new technology and the ways in which it differed from previous heating solutions in everyday life.

Yet, there were considerable gaps in the market mechanisms and the resulting 'ecology of intermediaries' (Hyysalo et al., 2018) that the final consumers faced. Even in 2008, it took months for two users to establish reliable information for a particular siting location for a joint purchase (Heiskanen et al., 2014; Martiskainen, 2014): market information on ASHP was mostly based on supplier and installer (potentially self-interested) proclamations, rather than unbiased information provided, for example, by regime-based transition intermediaries or user intermediaries.

Later in the acceleration phase hardware retail chains included them as standard offerings with active marketing and information provision and some energy companies began to offer heat pumps as solutions for customers beyond the reach of district heating networks. The *niche intermediary* SULPU gained an increasingly legitimate position, connecting on the EU level to heat pump advocate organisations, lobbying, receiving the Finnish Government's Renewable Energy Action Prize in 2009, and playing a visible role in the setting up of the Finnish Clean Energy Association in 2013 (Virkkunen, 2017).

Just as importantly, however, the acceleration is associated with the emergence of new *user intermediaries*, namely Internet discussion forums that have had an important influence on market development with over 200,000,000 reads during 2006–2018 (Hyysalo et al., 2018). Local case-specific, isolated comparisons were insufficient in keeping pace with the rapidly evolving markets and ASHP technology. The Internet forums, as user intermediaries, accumulated information on sales, scaling, installation, maintenance, troubleshooting, efficiency, and on the reliability and credibility of suppliers and installers. In doing so, the forums provided qualifying market information, acted as a backchannel for complaints and improvement needs, and provided evidence of value against counter claims from outside the niche (i.e. translated interests between different parties, and added institutional support) (Hyysalo et al., 2018). These *user and niche intermediary activities* helped re-contextualise the standard technology to national specifics of colder climate and seasonally more varied use than elsewhere.

By 2018, 800,000 heat pumps were installed, which is approximately 60% of the total residential building stock to which heat pumps are applicable in Finland (Sulpu, 2018; Hyysalo et al., 2018). The market institutions and technological development appear mature with steady linear growth in installations. This development has destabilised oil and direct electricity heating in Finland and began to destabilise the hegemony of district heating as 'the only viable option' in urban areas. Taken together, heat pumps have progressed to the end of their acceleration phase in Finland and are likely to soon enter the stabilisation phase of transition.

4.3. UK low-energy homes: an expanding ecology of intermediaries, failing to fully accelerate

4.3.1. Pre-development (1970–1998)

The UK low-energy new homes niche traces back to the 1970s, initiated by the oil crises and search for alternative lifestyles. Pre-development was characterised by multiple local experiments with new housing materials and concepts such as autonomous (Vale and Vale, 1975) and solar (McVeigh, 1983) houses. After two decades of pre-development, few intermediaries operated in the field (Fig. 1). The Centre for Alternative Technology (CAT), a charity established in 1973, is the longest-standing *niche intermediary* for UK low-energy homes. Through its low-energy building pilots, it contributed to articulating expectations and visions, with a long-term influence on both policy and practice. It also shared learning, and undertook capacity building by running masters courses and acting as a location for many student visits.

Building Research Establishment (BRE), a government agency and *regime-based transition intermediary* from 1972 until its privatisation in 1997, was another important intermediary. It was regarded as influential in exchanging knowledge and supporting learning processes through aggregating and disseminating information on zero carbon building; a function that diminished after privatisation (Kivimaa and Martiskainen, 2018).

Milton Keynes Development Corporation (MKDC), established as a government agency in 1967 and responsible for developing a new 'garden city', was also an important *regime-based transition intermediary* that from 1976 incorporated an energy consultative unit. It contributed to the articulation of expectations and visions, exchanging knowledge and supporting learning processes, and stimulated the emergence of new intermediaries in the area. MKDC developed, piloted and tested energy efficient housing concepts at a larger scale than before (Byrne, 2015).

Research and development conducted by MKDC fed into the development of low-energy standards by National Energy Foundation (NEF), *niche intermediary* and an independent charity, established in 1990. NEF, in turn, articulated expectations, visions and demands through practical projects, developed a national home energy-rating scheme, and supported learning for low-energy building (Kivimaa and Martiskainen, 2018). NEF also took a further intermediary role, in recommending installers to users (Caird et al., 2008). NEF managed a network of 30 Energy Advice Centres on behalf of Energy Saving Trust (EST, *regime-based transition intermediary*) that gave information on home energy efficiency (NEF, 2014).

EST, established in 1993, received funding from the government until 2012. During its governmental mandate, EST provided institutional support for home energy efficiency policy. It was also at the forefront of home energy efficiency advice (Mallaburn and Eyre, 2014), creating networks via the Energy Advice Centres. EST exchanged knowledge and supported learning processes via its research activities, e.g., by providing guidance and conducting field trials of new heating technologies (EST, 2006, 2013).

Fluctuating, and at times weak, policy support characterised pre-development. In periods of weak policy, new non-state intermediaries, including the Association of Environmentally Conscious Buildings (AECB) and Bioregional, emerged to create demands and expectations for stronger policy, and show possibilities through pilots (Kivimaa and Martiskainen, 2018). The increasing number of intermediaries is evident in late pre-development (Fig. 1).

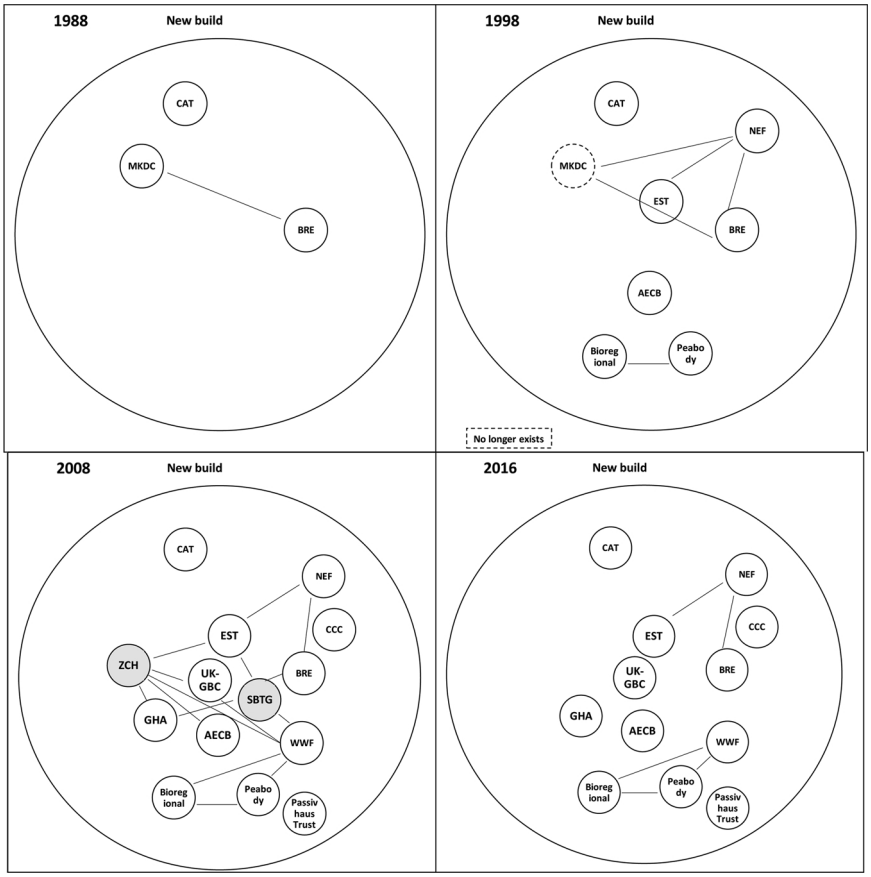

Fig. 1. Changing ecology of intermediaries for low-energy new build homes; network intermediaries highlighted in grey (Adapted from Kivimaa and Martiskainen (2018)).

4.3.2. Acceleration (1999–2018)

Acceleration began in 1999 through new vision building, influenced by international and national climate change commitments and the 2002 EU Directive on the energy performance of buildings towards "nearly zero energy" (Kivimaa and Martiskainen, 2018). Learning was generated in new networks and high-profile projects (Lovell, 2007). This led to substantial policy commitments in 2006 with the announcement towards zero-carbon new homes from 2016 onwards, and with the 2008 Climate Change Act (Kivimaa and Martiskainen, 2018). These changes stimulated the emergence of new intermediaries and stronger networks of intermediaries.

WWF-UK was active as a *systemic intermediary* in creating expectations and visions. In 2002, WWF-UK's 'One Million Sustainable Homes' campaign demanded a public commitment from the UK government to develop a million 'sustainable homes' (HM Government, 2014) and standardise the practice by 2012 (WWF-UK, 2006). WWF-UK took an intermediary role, being an insider in policy processes and the only NGO in government-set Sustainable Buildings Task Force, and auditing sustainability progress in 12 large building firms (Pickvance, 2009).

Following the 2006 announcement, a *regime-based transition intermediary* Zero Carbon Hub (ZCH), partly funded by the government, was given the task to plan for the delivery of zero-carbon homes with key stakeholders, translating the broader aims to a plan of practice. ZCH created and brokered a network of stakeholders (including other intermediaries) to work towards articulating expectations for zero-carbon homes. It supported learning processes by undertaking projects on the performance and overheating of buildings. While it gave institutional support for the build-up of zero-carbon policy, some have argued that it did not achieve the changes required for a zero-carbon transition. ZCH was abolished in 2015 simultaneously with the zero-carbon homes target being removed.

After 2006, new non-state *niche intermediaries* emerged, including the UK Green Building Council (UKGBC) and Good Homes Alliance (GHA), while many earlier intermediaries continued to operate. UKGBC wanted to create cohesion, in the form of a joint vision for a disparate sector, effectively consolidating the niche (Kivimaa and Martiskainen, 2018). It became active in networking, policy lobbying, aggregating learning, and disseminating experiences from completed projects (Kivimaa and Martiskainen, 2018).

Multiple intermediaries worked to advance the niche on the ground. For example, Bioregional, a social enterprise, acted as a *niche intermediary*, developing low-energy housing concepts through piloting them in practice and forming visions, expectations and learning that influenced policy development locally and nationally (Kivimaa and Martiskainen, 2018). In its building projects, Bioregional also employed *process intermediaries* to realise this vision in practice (Martiskainen and Kivimaa, 2018).

Table 4
Summary of changing intermediation in illustrative cases.

	Dutch automobile	Finnish heat pumps	UK zero carbon homes
Pre-development	Early niche intermediary (NAC) experimenting and networking via racing.	Initial introduction fails (no intermediaries).	A small number of intermediaries engaging in piloting, vision creation, learning and aggregation of knowledge. Towards end of pre-development a new public intermediary and several private intermediaries emerge.
Early acceleration	Emergence of a strong intermediary (ANWB) conducting niche and user intermediary functions; articulating demands and creating user standards.	Second introduction aided by establishment of niche intermediary (SULPU); articulating a vision, translating knowledge, improving reliability to installations, educating companies. A growing ecology of regime-based and user intermediaries; aggregating and translating knowledge. Significant information/intermediation gaps.	A systemic intermediary influential in advocating policy change. A higher number of intermediaries and stronger networks are created, partly resulting from supportive policy change. Vision building and consolidation, networking, translating and institutional support become important intermediary functions.
Late acceleration	Strong intermediary (ANWB) continued and conducted functions of niche, user and process intermediaries; forecasting diffusion; representing, educating and disciplining users. ANWB and NAC contributing to a (powerful) lobby for national infrastructure to accommodate car growth.	A shift in SULPU's role from a niche intermediary towards a regime-based intermediary; successful institutional support activities. An emergence of internet discussion forums as effective user intermediaries aggregating information and increasing legitimacy.	N/A
Stabilisation	ANWB turned into a regime intermediary promoting and facilitating car use for everyone, e.g. build of supportive service infrastructure.	N/A	N/A

User intermediaries, including the 'Eco Open Houses' events in Brighton, that facilitated the opening up of low-energy homes for others to visit, exchanged knowledge from projects, supported learning and helped to build visions of what is possible but with concrete attention to users' needs. Local authority sustainability officers acted both as important *regime-based transition intermediaries,* providing institutional support for local projects, and *process intermediaries* translating between novel solutions in the projects and the planning regime requirements.

Upscaling and further acceleration have not taken place, as much development halted after significant policy changes in 2015. Today a limited number of new low energy homes exists. The Low Energy Buildings Database, for example, lists only 132 residential (public and private) new builds (LEBD, 2018) against a housing stock of 28 million.

4.4. Cross-cuttings insights on case illustrations

Our illustrations highlight the significance of intermediation in accelerating and strengthening transition, and show how intermediation changes as transition progresses (Table 4).

Even the UK low-energy homes transition, which has not advanced to late acceleration, shows the importance of intermediation in moving from pre-development to early acceleration: Fewer and less connected intermediaries existed in pre-development, while a strong *systemic intermediary* (WWF-UK) significantly influenced the beginning of acceleration; soon characterised by an expanding ecology of intermediaries strengthening the vision of the niche and building institutional support. For heat pumps, pre-development was associated with lack of intermediaries. Instead, a central niche intermediary and a nascent (even if gap-ridden) ecology of intermediation supported the early acceleration. The acceleration stage is associated with a maturing ecology of intermediaries, such, that a relatively mature market, technology and stable intermediation was in place for stand-alone residential GSHPs by around 2010 and for ASHPs by roughly in 2015. Dutch automobility was significantly shaped by a strong niche intermediary, effectively a system builder (cf. Musiolik et al., 2018) adopting also other intermediary roles over time.

The illustrations also show that *systemic intermediaries*, while important for sustainability transitions (van Lente et al., 2003; Barrie et al., 2017), do not play a direct part in every transition. Perhaps, they are less needed for simpler technology-oriented transitions, such as the diffusion of cars and heat pumps, than for more complex socio-technical configurations.

5. Discussion

The stylised transition models we used to provide clarity to the reviewed literatures on intermediaries (Section 3) and the illustrative cases of three transition processes (Section 4) open a perspective to intermediation in transition that complements the reviewed literature. The orderly progression of transition from one phase to another is foremost an ideal type, and there may also be regressions. Nonetheless, an analysis of a completed transition from a perspective of a single key intermediary, in the case of Dutch automobility, illustrates well the changing roles a key intermediary can play in different phases. An analysis of a completed transition

requires long-term historical data which is unlikely to feature detailed evidence of all other intermediaries and their interrelations. Thus, an analysis of a single intermediary through a transition matches the simplified view to transition illustrated by the meso and macro level models. Whilst this is instructive and clear, also richer insights on the diversity of intermediary actors and their mutual relations in different transition processes are needed.

To this aim we examined on-going transition processes pertaining to heat pumps and low-energy homes, tracing the contributions of different actors from both historical and contemporary studies. Finnish heat pumps have introduced a transition in home heating, progressed to the late acceleration stages (of about 60% of maximal diffusion), while the acceleration of UK low-energy homes transition has halted. Whilst the heat pumps case features a stop-start pre-development phase, the low-energy homes case shows an ongoing transition process in its full complexity and without certainty of reaching full acceleration. This reflects the recognition that many transition processes do not progress linearly, but can become regressive (e.g. Loorbach et al., 2017). The cases, together with the literature review, thus, give insights to the nature of intermediation in transition processes. Even as these materials do not allow for a mechanistic comparison, they enable spelling out cross-cutting contributions.

The first cross-cutting finding from our literature review (Section 3) and illustrative cases (Section 4) is that intermediation in transitions is predominantly undertaken not by single actors but by many intermediaries who have different remits and competencies. These can lead to synergy and complementarity between intermediaries, but also gaps in the resulting ecology of actors who intermediate transition. This confirms earlier work by Stewart and Hyysalo (2008); Klerkx and Aarts (2013); Martiskainen and Kivimaa (2018) and Mignon and Kanda (2018). Shifts in the ecology of intermediaries are particularly noticeable in between transition phases, when intermediary activities move from local and often championing intermediation activities (Hermans et al., 2016; Martiskainen and Kivimaa, 2018) to trans-local/national/international scale; the latter requiring different data aggregation and communication styles and capabilities from intermediaries.

The effectiveness of such an ecology of intermediaries proved difficult to assess through our illustrative cases. Some tentative evidence emerged on complementary and synergistic effects, but also the lack of these. The UK low-energy homes transition showed slow acceleration despite a significant number of intermediaries operating with different mandates and at different levels, but partly lacking synergy. The Finnish heat pumps case had more synergy benefitting from a strong niche intermediary, an industry association established to support it, but also from emerging user intermediaries addressing missing functions related to new technology and markets. The tentative evidence, thus, suggests that there are many intermediary functions to fill but that more intermediaries is not necessarily 'merrier' – our second cross-cutting finding. Third, we can also conjecture whether reaching adequate intermediation is easier in contexts that are characterised by one focal alternative technology, such as an automobile or a heat pump, rather than in more varied socio-technical configurations such as low-energy housing, featuring multiple alternative technology options and highly localised variation at user sites.

The causality in transition processes is difficult to assess, because the processes are complex and multidimensional (e.g. Geels, 2005), also affecting the analysis of the contribution of intermediaries. Moreover, it is harder to attribute the influence of particular factors in a 'failed' transition than a successful one. For example, is the failure of UK low-energy homes transition to accelerate, partly, because of the absence of sufficiently strong single intermediaries, or a gap in the overall ecology? Or have intermediary activities oriented at destabilisation of the existing regime perhaps been insufficient? Or, are other factors making the transition so difficult, that this difficulty has led to an extremely high number of intermediaries extending over different functions and levels of action, without having one coherent voice for the sector?

Given the conceptual nature of this article and the tentative evidence offered through the illustrative cases based on re-interpretation of existing research, further empirical research is required: to (a) systematically compare intermediation in more and less successful transitions; (b) analyse intermediation in transitions engaging in single versus multiple technologies and/or technology-service combinations; (c) gain insights on the functions/activities of transition intermediaries in destabilising incumbent regimes and the interplay with other forces of destabilisation; and (d) analyse patterns in terms of redundancy or scarcity of intermediaries in transition phases and what that implies for potential complementarities and synergies as well as gaps and sufficiency in ecologies of intermediaries. To that effect, our conceptual framework (Table 2) serves as a starting point to show the patterns and pathways of intermediation across levels, phases and intermediary types.

6. Conclusions

In this article, we made a new opening in the transitions literature to study how intermediaries, i.e. actors connecting multiple other actors (e.g., innovation funders, energy agencies, NGOs, membership organisations, new kinds of networks or internet discussion forums – but typically not, e.g., profit-seeking established firms or technology inventors), and intermediation change in different phases over the course of socio-technical transitions. We developed a conceptual model on what different types of intermediaries do in different transition phases, followed by empirical illustrations of transitions in automobility in the Netherlands, heat pumps in Finland, and new low-energy homes in the UK.

What becomes clear on the basis of both the conceptual literature review and the empirical illustrations is that each transition is unique. Thus, it would be difficult to prescribe universal theory or policy messages pertaining to intermediaries in transitions. However, we want to postulate the following:

First, the *pre-development phase* requires intermediaries to get things going. Little seems to happen without these actors who create spaces for experimentation, connect actors, and aggregate, translate and disseminate new knowledge. Moreover, the pre-development phase may be shorter when there are strong systemic or niche intermediaries that can create powerful networks to enable early change in market and regulatory institutions.

Second, our empirical illustrations demonstrate that such powerful intermediaries are long-term actors who effectively employ *functions* of vision creation, networking, institutional support (e.g. standard creating), and capacity building (educating companies and citizens). Some may also engage in changing the regime by preventing strategic games by others and destabilising the institutions and attractiveness of regime-based alternatives, i.e. engaging in strategic games by themselves.

Third, *intermediaries form ecologies* between suppliers, consumers and various governance bodies. These ecologies are subject to change in the course of transition, and their effectiveness is different in each phase. They vary based on technology and industrial domain and change in the course of the transition process, regarding the activities of particular intermediaries and the ecology overall. The cases suggest that a strong championing intermediary may have importance for advancing transitions, and a lack of one can hamper the progress of transition. We can conjecture on the basis of Dutch automobility and Finnish heat pumps that this is because of improved coordination among the intermediating actors, which such a championing intermediary can bring.

Fourth, *systemic intermediaries* have important roles throughout the transition, while other intermediaries, particularly *process* and *user intermediaries,* have more temporally limited roles and experience shifts in the role they play. *Niche intermediaries* cease to exist after acceleration, or transform their role to a *regime intermediary* (even resisting change) in the new stabilised regime. *Systemic intermediaries* are likely to look out for new issues requiring their attention and pulling off from activity related to a particular sociotechnical system or subsystem after early acceleration or at latest in the stabilisation phase.

Fifth, a focus on *niche and regime levels* provides insights into how intermediation changes. At the niche level, intermediation focusing on support and opening space for experimentation during pre-development reorients towards aggregating knowledge, replicating projects and pooling resources for acceleration. *User intermediaries* become increasingly important as transition progresses. At the regime level, intermediation during pre-development concentrates on articulating demands and demonstrating the variety of options, but moves towards creating political and institutional space and capacity building in acceleration. In acceleration, both *regime-based transition intermediaries* and *niche intermediaries* become important actors at the regime level, some niche intermediaries making a transition to new regime intermediaries (shown by the automobility and heat pump illustrations).

Sixth, when looking at *translation at the niche-regime interface*, all five types of transition intermediaries play a role. In pre-development, process intermediaries translate regime priorities into the plans of local projects, system intermediaries create institutional space for experimentation, regime-based transition intermediaries allocate funding for experimentation, and niche intermediaries articulate early expectations for regime change. Actors taking hybrid roles between niches and regimes are often yet to form. In acceleration, niche intermediaries aim to develop shared rules, standards and infrastructure for the niche, strengthening its position in the regime (visible in all case illustrations). New process intermediaries emerge as existing actors adopt transition functions (e.g. architects translating new regulations to practice). Similarly, regime-based transition intermediaries translate between the regime and new niches, and user intermediaries between users and suppliers of new solutions. Systemic intermediaries begin market creation, and possibly attempt to destabilise the existing regime; while sometimes niche intermediaries become so powerful they can do this. In stabilisation, the dichotomy between niche and the regime disappears as niche actors may become new regime actors and markets become established.

The policy action related to intermediaries has usually been one of founding new intermediary actors in cases of apparent need, or adding new intermediary functions for existing intermediary actors, for example, when new preferable technologies enter markets (van Lente et al., 2003). Our analysis suggests that policy (or niche actor) intervention could go beyond such obvious cases, to mapping whether relevant intermediaries exist in the ecology of intermediaries and whether their remits and interlinkages are functional enough. It further suggests paying attention to the changes needed in intermediary activities when the transition progresses, given the likely alterations in the market and technology characteristics and novel practices that are associated with it.

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