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Scripts in transition: Protective spaces of Indonesian biofuel villages

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ABSTRACT

This paper studies the development of biofuel village pilot projects in Indonesia. Despite the central government's political and financial commitment to the projects, the projects failed to survive and produce sustainable effects. In order to understand why the projects were stalled, this paper traces how the design of Indonesia's biofuel policies shaped the actual socio-technical configurations of the projects. To trace this relationship between the policies and the actual project configurations, we develop a framework that combines the concept of protective space from transition studies and the concept of script from actor-network theory. The concept of script allows us to investigate how the designs of protective spaces and of the experimental projects are enacted through non-coherent processes involving misunderstandings and shifts in meanings between narratives and things (e.g. between policies implemented and the machines put in place). Our analysis makes manifest the non-linearity of the relation between the design of a protective space and the actual practices engendered. This non-linearity emerged through changes in direction brought about by the central government's inability to stretch and transform the local environment in accordance with the policy design and through changes in individual actors' interests in the projects.

1. Introduction

Strategic niche management (SNM) approach was introduced as a policy strategy to develop protective spaces that allow the experimentation for certain applications of a new environmentally sustainable technology (Kemp, 1994; Kemp et al., 1998; Schot and Geels, 2008). The approach assumes that if such protective spaces (or niches) were constructed properly, they would become building blocks for a socio-technical transition towards sustainable development. Smith and Raven (2012) suggest that despite emphasis on protective spaces, little attention has been given to the concept of protection in the transitions literature. Therefore, they propose a framework that conceptualises protective space as operating through the three processes of shielding, nurturing and empowering. Shielding provides temporary relief for niche innovations against selection pressures from the incumbent regime; nurturing focuses on learning, articulating expectations and networking between actors; while empowering focuses on activities that make niche innovations competitive vis-a-vis existing dominant regimes.

Verhees et al. (2013), Kern et al. (2014) and Smith et al. (2014) use this framework to show how proponents of a particular technology (e.g. solar PV, offshore wind) try to shield, nurture and empower innovations in different contexts (e.g. R&D labs, off-grid locations and the built environment). In this article, we aim to investigate not only the effectiveness of protective spaces in shaping the desired socio-technical configurations in different contexts, as done by previous studies, but

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also the relationship between the socio-technical configuration *prescribed* by the design of protective space and the actual socio-technical configuration that is *materialized*. Akrich (1992) suggests that designers of a technology make assumptions about the behaviour and environment of future users, the specific group of actors at which the technology or product is directed. These assumptions together with designers' interests are scripts (or scenarios) inserted by the designers into a technology or, more generally, into a thing. The concept of script highlights the reciprocal relationship between in-scription, i.e. activities of embedding a script into a technology, and de-scription i.e. activities to interpret the technology and to materialize this interpretation in practice (Akrich, 1992).

Building on these insights, this paper develops a framework to study how policy designers' plans for shielding, nurturing and empowering biofuel technology relate to the users' interpretation and materialization of the policies (and the technology) in practice. In the transitions literature, a similar analysis of the recursive relationship between a 'global' vision and local practice has been done by Raven et al. (2011), using Callon's (1986) concept of translation. They study different mechanisms through which local actors are able to contest and to negotiate development directions of a 'global' project. Through the concept of script, we extend the articulation of recursive relationships between design and (local) use not only as a process of achieving coordination or of building shared interest as suggested by Raven et al., but also as a process of interacting while misunderstanding (cf. Star and Griesemer, 1989; Brown, 2002; Stark, 2009). Stark for example argues that actors interact (and collectively act) without necessarily having to agree on the meaning of the objects (things or words) exchanged (e.g. countries may disagree over a 'global' climate change framework but develop clean energy technologies anyway for economic growth reasons). The concept of script avoids the requirement of a shared problem-definition or shared expectations since it focuses on things (in which the scripts are inscribed) that facilitate actors' interactions and how these things shape actors' practices (through de-scription).

Using a framework based on scripts, we analyse the development of Indonesian biofuel villages program. In 2006, the central government issued a presidential instruction requesting 13 government institutions, governors and district-heads to promote biofuel development as an alternative energy source. In 2009, this instruction allowed the central government to initiate three pilot projects of 'Calophyllum-based Energy Self-sufficient Village'. For these projects, the central government provided a 'biofuel package' composed of a biofuel processing unit, chemicals to process biofuels, operational funds for 3 months and technical training to farmers. By early 2011, none of these pilot projects had survived. At the end of 2011, when the local government of Purworejo involved an entrepreneur from Yogyakarta, one of the pilot projects started to operate again. The different protection mechanisms in the form of political and financial support and activities of including and excluding actors in the projects make this an apt case for examining the relationship between design of a protective space and its actual practice.

The conceptual framework and methodology are explained in the next section before we present the analysis of an energy self-sufficient village (Section 3). We end this paper with a discussion and conclusions section.

2. Conceptual framework

Transition studies focus on shifts from one socio-technical regime to another (Geels, 2011). A regime is a set of rules embedded in socio-technical practices, formal/informal institutions and existing infrastructures (Rip and Kemp, 1998). Transition studies assume that radical innovations develop within protective spaces (often called niches) in which they are nurtured and improved. These protective spaces (e.g. R&D laboratories, demonstration projects, market niches) are necessary because regimes select against radical innovations that have a mismatch with incumbent interests, infrastructures and institutions. By facilitating experimentation, protective spaces allow for modification and deviation from practices of the existing regime. The notion of protective space thus offers an analytical tool to understand how new technologies can (and are able to) survive despite hostile selection environments of the regime. In this paper, by combining the notion of protective space with in-scription and de-scription, we aim to provide an insight into how the design of protective space shapes actual socio-technical configurations.

2.1. Protective space

Smith and Raven (2012) define protective space as being constituted by the three processes of shielding, nurturing and empowering. Shielding focuses on how support for an innovation came into place, who lobbied for it and how it was agreed upon. Nurturing foregrounds how financial as well as cognitive support improves the innovation by expanding the actor-networks and shaping their expectations and learning. And empowering focuses on how the different types of support were institutionalized by reconfiguring the incumbent regime. The three processes of shielding, nurturing and empowering may be initiated at the same time. Thus they do not have to sequentially follow each other, but may be coterminous and intertwined with each other (see also Verhees et al., 2013; Kern et al., 2014). Boon et al. (2014) for instance, introduce the notions of niche creation, niche maintenance and niche phasing out to regroup activities referred in shielding, nurturing and empowering. Despite this interdependence, the three concepts are meant to help innovation analysts in delineating different processes that make up the protection of a 'sustainable' innovation.

Smith and Raven (2012) define shielding as the work to ward off competitive pressures from existing regimes and to create and sustain a space for experimentation. Shielding covers activities such as mobilizing pre-existing financial resources and lobbying for subsidies (Verhees et al., 2013) and performing policy that enables early research, experiments and pilot/demonstration projects (Verhees et al., 2015). Based on its relationship to a targeted innovation, two types of shielding can be distinguished—active and passive. Active shielding refers to the mobilization of financial support for an innovation and its further development. It could also include promotion of the innovation's use despite (temporary) poor performance. Passive shielding refers to mobilization of non-targeted spaces that indirectly support an innovation such as implementing research in favourable geographical locations (Verhees et al., 2013).

Nurturing involves the three sub-processes of learning, articulation of expectations, and networking (Smith and Raven, 2012). These three sub-processes have been extensively studied under the heading of 'strategic niche management' (SNM), where the parallel operation of and interaction between these three processes leads to sustainable innovation journeys (e.g. Schot and Geels, 2008). It is argued that actors embedded in a network with shared expectations are more likely to invest resources in an innovation project which gives rise to learning in local experiments (Geels and Raven, 2006). In turn, learning leads to a re-articulation of expectations as well as a re-configuration of niche networks.

Smith and Raven (2012) define empowering as process through which the protective innovation is able to break out of its protective space and able to compete with or reconfigure the wider regime. They identify two types of empowering in protective spaces. The first type is fit-and-conform where niche actors develop an innovation by adjusting its attributes in ways compatible with the prevailing regime. Fitting without changing the rules of the regime, however, may challenge the critical sustainability requirements since the innovation has to conform to existing structures. The second type of empowering is stretch-and-transform where niche actors modify the prevailing regime in ways favourable to the innovation. Through studying six low-carbon technology cases, Raven et al. (2015) observe that fit-and-conform strategies are more easily to enrol others' interests. Additionally, Levidow et al. (2014) show that empowerment can be used not only to investigate how an innovation is able to develop into a market niche but also to investigate tensions within research and development network.

To distinguish between different protective spaces over time, Verhees et al. (2013) use actor categories (e.g. R&D, PV industry, autonomous PV system) constituted by their practices involved in shielding, nurturing and empowering PV innovations. However, by doing this, they direct attention away from tensions and contestations between different technological options (e.g. nuclear versus solar PV) or between the actors' different priorities. More recently, Smith et al. (2014) have focussed on the contestation and tensions between contents and contexts of an innovation. Through the use of narratives, they show how an innovation's proponents expand their protective space not only by improving technological performance, or the content, but also by changing the existing socio-technical configuration (the context). Raven et al. (2015) add to this argument by showing that advocates have attempted to secure innovation resources by situating their narratives to broader socio-political agendas. Their study shows that success or failure of innovation also depends on actors' network where the same narrative may have different effect, depends on the messenger.

2.2. In- and de-scription

To move from narratives to things, Akrich (1992) uses the notion of script as something that is not only embedded in narratives but also things (e.g. machines, bodies and policies). She argues that designers of a technology (or policy) anticipate the interest and motives of future users and attempt to embed their anticipation as a script in the technology. According to Joerges (1999), in addition to the designers' assumptions about user preferences, designs are also shaped by other elements such as standards, regulations and limitations of the current technology. We treat these elements together with the designers' assumptions as the scripts that are inserted into a technology or policy through *in-scription*. The in-scribed scripts are conveyed to users as the 'right' ways of using an object (a technology or a policy). This process of limiting deviation from a script is facilitated by attaching other things (e.g. incentives, weights, notifications) to an object and circulating them among users (Latour, 1992). As an illustration, Latour presents a case of a hotel manager with the script of having his customers leave their room keys at the front desk. First, s/he in-scribes this message into a notification board to remind the customers to leave their keys, but most customers carried the keys outside the hotel. Then s/he in-scribed the message into a metal weight attached to the key ring, and most customers left their keys at the front desk. By attaching an appropriate metal weight, the hotel manager was able to limit deviation from the script of leaving the room keys at the front desk.

The concept *de-scription* refers to activities of interpreting an object and to turn this interpretation into practice. In the example of the hotel key, de-scription occurs differently in the two attachments (of two different things to the script) attempted. In the first case, when the key was only attached to a notification board, customers deviated from the script by taking the keys out of the hotel. While in the second attempt, when the keys were attached to metal weights, they were left behind at the front desk and most users adhered to the script.

Through the concepts of in- and de-scription, we are able to follow multiple interpretations of a protective space by its users and how these interpretations are actualized in practice. The combination of protective space with in- and de-scription provides us with systematic tools to trace recursive relations between scripts (e.g. energy crisis, poverty alleviation), the things (e.g. policies, machines, business models) into which the scripts are in-scribed, and de-scriptions by users. This conceptualization differs from that of Raven et al. (2011) who focus on the relation between a generic 'global' model and local practices using the concept of translation (Callon, 1986). Translation highlights coordination between actors by the generation of a unified perspective attributed to all involved actors (who face a shared problem), while the concept of script focuses on the production of multiple points of view and eventually multiple practices (through de-scription) (see Fig. 1).

These two distinct conceptualizations afford different understandings of (non-linear) changes produced in technological practices, from design to actual implementation. The concept of translation allows one to foreground the contrast between *shared* expected outcomes and actors' collective practices actualized, while script affords contrast between *individual or shared* expected outcomes and actors' individual practices (see Fig. 1). The former describes controversy as an outcome of actors' betrayal of a shared collective, while the latter describes controversy as an outcome of actors' different and possibly conflicting practices derived from the 'same' in-scription. By following multiple interpretations (of a script) and practices, the concept of de-scription allows us to capture how certain actors escape domination, rather than how an actor becomes dominant by mobilizing other actors as resources (through successful translation).

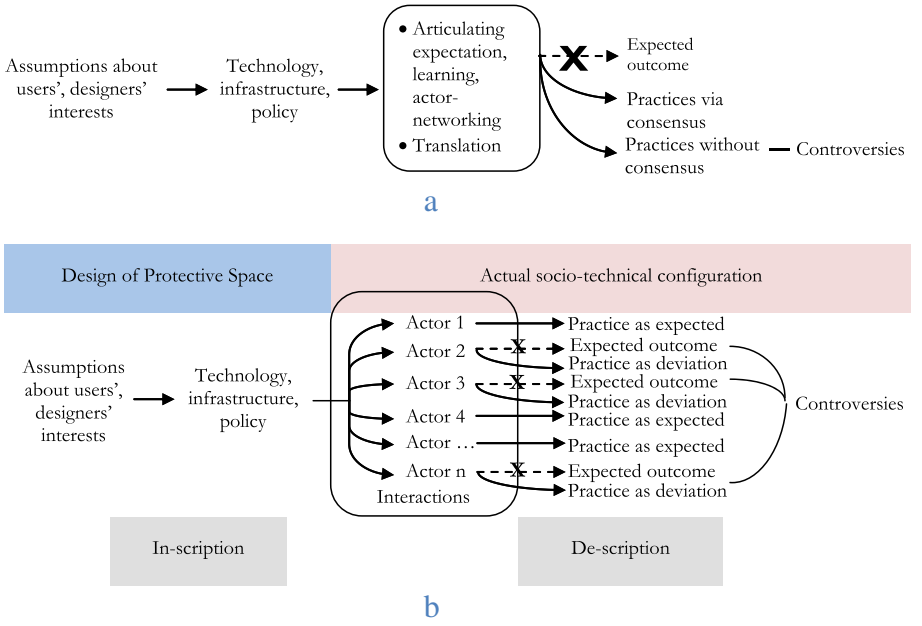

Fig. 1. a. Translation. b. Script.

2.3. Methodology

We use a case study approach as a research strategy since it investigates a contemporary phenomenon in its real-life context (Yin, 2009). We use multiple data sources, all enacted/collected by the first author: a) 43 interviews; b) field work in districts of Grobogan, Kebumen, Yogyakarta and Purworejo (see Fig. 2) for a total of 3 months spread out between October 2010 and May 2012; c) extended interactions with a local entrepreneur, the local government of Purworejo and the local NGOs through emails, phone calls, and text messages; d) a national workshop in Bandung and two local workshops (in Purworejo and Yogyakarta); and e) written materials such as policy documents.

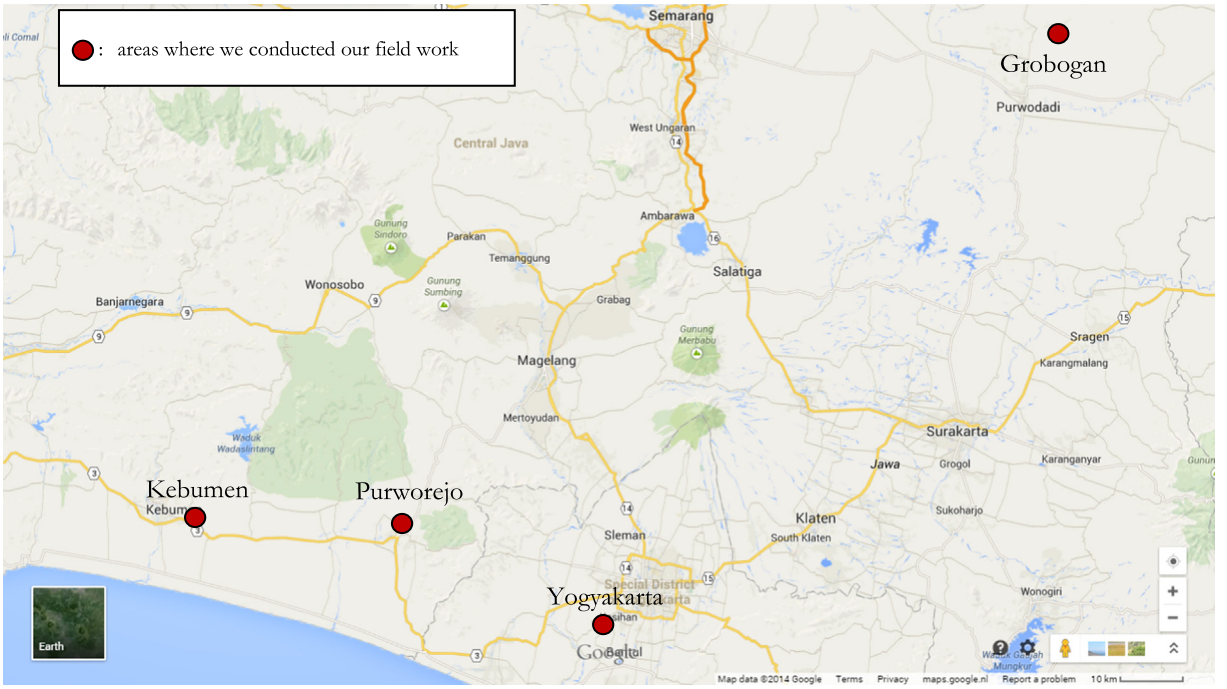

Fig. 2. Fieldwork areas.

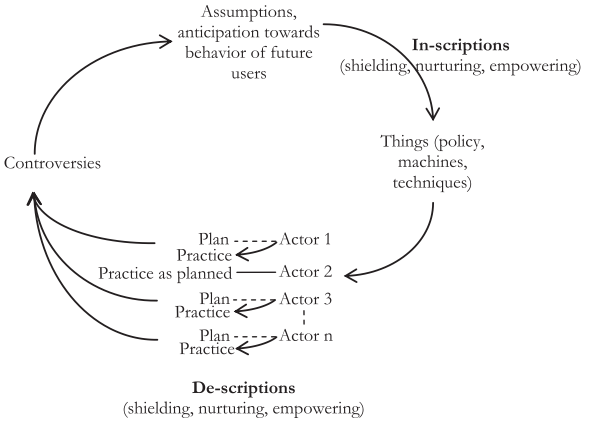

Fig 3. The cycle of in-scription and de-scription.

Our main focus is Purworejo district. While the experimental projects we studied are called energy self-sufficient villages, in practice these projects were managed by the district government. For continuity of the projects, the district government often needed support from other areas.

We started our coding by identifying the scripts of protective space, the assumption and anticipations towards behaviour of future users, which was followed by identifying what things were being mobilized and by investigating the degree to which these things bound the users to follow the scripts (See Fig. 3). In building the case, we move from in-scription and de-scription where disjunctures, between what is planned by the designers of the protective space and how the users de-script the protective space, stimulate the emergence of controversies. Based on our coding, we capture in-scription and de-scription, as outlined in Table 1 below.

3. Biofuel villages project

In March and October 2005, to reduce the government's fiscal deficit, the Indonesian president increased the national oil price by 29% and 114% respectively. According to some calculations, this policy increased unemployment and poverty (Amir et al., 2008). The Indonesian Statistics Agency reported that in 2005 the number of poor people was about 35 million, but in March 2006, it had soared to 39 million. The oil price rise triggered mass demonstrations in over 10 cities, take-over of a radio station and protests from bus drivers, vendors and factory workers (IISD, 2010). In response to the demonstrations and the calculations, the President held a limited cabinet meeting in July 2006 to launch what he called as a 'Post-crisis New Deal' (Yudhoyono, 2006). The aim of this New Deal was to devise new policies and strategies to create jobs and rescue those suffering from (fuel) poverty in rural areas. In executing this form of protection, the central government adopted a kind of 'Fordism,' where the policy to intervene at the local level was based on a standardized form of mass production. In the villages, where national policy was materialized into machines and practices, this approach did not work unless local actors appropriated the 'global' model into their local context. In the following, we contrast the assumptions in-scripted by the central government in a biofuel development policy program and its de-scriptions by the users of the project.

3.1. In-scriptions

In executing the Post-crisis New Deal, in 2006, the central government inscribed their ambition of reducing poverty, creating jobs and solving the oil price crisis into a set of policies to support biofuel development. This support staved off selection pressures from the fossil fuel regime and provided a space for experimentation. Scientists in Forestry Research and Development Agency (FORDA), the Minister of Research and Technology, the Ministry of State-owned Enterprises and some of the district governments utilized this space to do research on various energy crops, to form a special taskforce to increase biofuel production efficiency and to urge all state-owned corporations to support biofuel production (Amir et al., 2008). In 2007, these scattered activities stimulated the emergence of energy self-sufficient village (ESSV) projects, under which district actors received machines, training and 3-month financial support from the central government to run the production of biofuels.

3.1.1. Shielding: Setting the context

According to the Ministry of Energy and Mineral Resources, the ESSV project was motivated by the fact that 45% of the residents of more than 70,000 Indonesian villages were living

Table 1
Concepts, things/actors and indicators for analyzing the relation between design and practice of protective space.

	In-scriptions	Things	De-scriptions
Shielding	What are the wider environments/context anticipated by designers of the protective space?	What things are being circulated to align other actors to support the proposed shield?	How do the actors include these things into their practices? What are the local contexts (and whether they are compatible with the designed content)?
Nurturing	What are the activities done by the designers with regards to mobilize their script between heterogeneous actors (e.g. competitive, cooperative)?	What things are being circulated to align other actors to support learning, networking and articulating expectation?	How do the things stimulate learning, networking and articulating of expectations? How are actual lessons, networks and expectations different from those anticipated by designers?
Empowering	What are the activities done by the designers with regards to institutionalization of the protective space (stretch-and-transform or fit-and-conform)?	What things are being circulated to lock other actors to institutionalize the space?	How do the users institutionalize things of the protective space (and whether it follows the design or not)?

below the poverty line.[1] The ESSV project was meant 'to fulfil the village's needs on energy, to create jobs and to alleviate poverty through optimizing local community capability' (MEMR, 2007:18). This policy did not articulate what the Ministry meant by the notion 'local community'. The use of a seductive yet meaningless 'non-operational buzzword' has probably not helped the project to operate on its own terms (Cornwall and Brock, 2005).

This political shield of governmental commitment was supplemented by financial and technical shields to build a biofuel processing unit, to fund its operational costs for the first 3 months, and to train the local actors to become capable of operating biofuel machines. This project was built on a business model that would benefit the farmers and the biofuel producer (FORDA, 2008). The model was designed to shift rural development from agriculture to industry where farmers were expected to add value to their crops before offering them for sale. For biofuel processing, the farmers were expected to receive an additional income of 128 dollars per month and the biofuel feedstock (Calophyllum fruits) collectors could receive an additional income of 11 cents per kilogram. To ensure availability of buyers, the central government instructed state-owned enterprises to buy the biofuel produced in villages.

3.1.2. Nurturing: Setting the assumptions

The ESSV program opened up a space for FORDA scientists to do research on forest-based energy crops. They used this space to focus their research on *Calophyllum inophyllum* L. (*nyamplung*), an 8–20 m high, low branching tree. According to the scientists, Calophyllum seeds yielded 40% of their weight in oil (Sudradjat, 2008). Since 2008, they started conducting experiments to show that Calophyllum fuel met the Indonesian standard for biodiesel. The Calophyllum fuel was successfully used as a fuel in three road tests of 370 km distance without creating problems in conventional diesel engines. After receiving reports about these positive results, the Ministry of Forestry arranged an action plan for a Calophyllum-based fuel program. This action plan consisted of a list of recommendations to conduct research on energy consumption behaviour in villages, to open opportunities for local institutions to support Calophyllum development, to promote Calophyllum locally and to establish a biofuel business unit.

3.1.3. Empowering: Setting the strategy

The central government designed the protection of biofuel development by following the stretch and transform mechanism, under which the Ministry of Energy and Mineral Resources (MEMR) included biofuel development as part of their plan to develop alternative energy (Jupesta, 2012). The central government's interest to develop alternative energy was influenced by Indonesia's changed status from an oil exporter to a net oil importer since 2004. This pressure stimulated changes in Indonesian fiscal mechanisms, energy sources and types of consumed energy.

In designing a transition towards reduced oil dependency, the MEMR identified the Indonesian energy situation as being dominated by oil (52% of total energy consumption) and 43% of domestic oil consumption was imported (Yusgiantoro, 2007). The MEMR also noted that Indonesia had a high potential for biofuel feedstock supply and land that was suitable for biofuel plantations and access to proven biofuel technology. Therefore, it was argued that biofuel production was a suitable way to address the Indonesian energy crisis (Yusgiantoro, 2007). To institutionalize biofuel development, the central government issued several regulations that promote the supply and utilization of biofuels as alternative fuels (PI No. 1/2006), the formation of a National Team for biofuel development (PR No.10/2006), requirements and trading licensing guidance for biofuels as alternative fuels (MEMR Regulation No. 51/2006), reduction of income tax (PR No. 1/2007) and mandatory requirements for biofuel utilization.

3.2. De-scription: The practice of ESSV 1.0

De-scriptions refer to activities to interpret the objects (e.g. presidential instructions, machines) and techniques (including training) provided by the government for village residents as part of the protective space for biofuel development. To capture de-scriptions, we moved away from the policy documents, as well as from policy makers in Jakarta and scientists in Bogor, to Purworejo and Grobogan districts where the government set up its pilot project. The first thing that became apparent in the field was that the industrializing and standardized ESSV model did not work. The part-time operator of the local biofuel unit, whose main job was cultivating paddy and sugar, did not know how to handle a flow of chemicals, Calophyllum seeds and a biofuel market. Nevertheless, the operator did learn that in order to produce 1 L of biofuel, he needed many more Calophyllum seeds than stated in the business model. The farmers saw the Calophyllum seeds as another cash crop and not as an energy source for cooking since they used firewood that was freely available in their village. The district government was waiting for more subsidies from the central government since, due to its relatively high production costs, Calophyllum fuel was not able to compete with the fossil fuel price.

3.2.1. Shielding: Emergence of new biofuel activities

3.2.1.1. The Purworejo actors. Purworejo district, apart from Kebumen and Banyuwangi, was selected by the national government for Calophyllum pilot projects due to its abundant Calophyllum vegetation. In the 1950s, the forestry agency had planted Calophyllum trees along the southern part of Purworejo as wind-breakers in an area of 10.6 ha. This plantation was followed by similar activities on larger areas in 1977 and in 1980, resulting in 136 ha under Calophyllum in Purworejo in 2010. This area has rainfall between 1400 and 4000 mm with 3–10 wet months (>200 mm) and 0–6 dry months (<100 mm) (Bustomi et al., 2010). This distribution of land-use and rainfall influenced the harvest time for Calophyllum, which in the business model (in-scription) was assumed to be twice per year. During fieldwork in 2011, the pickers reported that they had already missed one harvesting time because of non-stop rain (de-scription).

In this area, majority of the land was classified as dry (1.6 million hectares), followed by paddy fields (289,107 ha), house and garden (72,049 ha) and forest (61,500 ha) (Bustomi et al.,

[1] He mentioned it in the biofuel conference in Brussels, July 5, 2007.

2010). In 2008, most people worked as farmers (5336 out of 5914 people), although not everyone owned land. The multiple land uses, different harvesting times for crops such as paddy, corn, tubers, vegetables and beans as well as access to forest land (where Calophyllum was to be found) all played a role in the de-scription process, often producing deviations from the shielding script, while affording the outcome that (some) farmers eventually became Calophyllum pickers. The local agrarian context (with its different harvesting times) in fact acted as passive shielding for the Calophyllum project in de-scription. To limit deviation from the script during de-scription, the local government of Purworejo planted 20,000 new Calophyllum trunks in an area of 50 ha.

3.2.1.2. The Bantul and Purworejo actors. An entrepreneur from Bantul used the biofuel protective space shielded by the central government to start a biofuel business. He started it in 2007 by creating a Calophyllum supply network by enrolling a *kyai*, an Islamic guru who usually has many students. Through this enrolment, the entrepreneur tried to mobilize the villagers to collect Calophyllum not only through financial calculations (and incentives/profits) but also through a cultural approach.

> "Based on our evaluation on the government's project, their projects never include [local] social engineering (to appropriate the central rhetoric into the local context). Therefore, we develop what we call as *ratib*, a local-historical story that allows the local people to associate themselves culturally and historically with Calophyllum," said the entrepreneur.[2]

In this de-scription that took the government's shielding script into an unexpected new direction, the entrepreneur performed an active shield by inserting the *ratib* into the *Merti Dusun* ritual. This ritual, done every year in Southern Java to honour the spirit of the earth, usually begins with the cleaning of the village as a symbol of life, followed by cleaning of the local cemetery as a symbol of death. On the following day, all villagers pay their respects to the spirits by performing puppet shadow play (*wayang kulit*) and *sinden*, a singing act accompanied by a traditional musical instrument called *gamelan*. People believed that if they did not perform this ritual, there would be a disaster in their village. The entrepreneur made an appeal to people's faith in the spirit of the earth by promoting Calophyllum as a tree that could conserve water. In addition, the entrepreneur and the kyai brought village representatives to Gunung Kidul, a dry area in Yogyakarta where an old Calophyllum tree was able to survive without much water. They translated the presence of this tree in the dry area into a message of Calophyllum as a blessed or holy tree.

The activities of enrolling the kyai and inserting the Calophyllum tree into local culture were relatively successful in creating an incipient supply network of 129 pickers in Purworejo and Kebumen, who collected 100 t of Calophyllum fruit per month. According to a household survey among farmers of Kebumen and Purworejo conducted by the Kyai, their maximum income was around 3.3 dollars per day, which they were able to supplement by more than 1.3 dollars per day through selling Calophyllum fruit. According to the Calophyllum pickers in Tegalretno village in Kebumen district, recruited by the entrepreneur, this additional income came largely through women's involvement in fruit collection. Calophyllum had enabled women to get an additional income since paddy and papaya were usually men's work and vegetables and vegetable-like 'crops' such as Calophyllum were women's work.[3] The kyai expected that this additional income would be very beneficial for farmers. In practice, however, the entrepreneur and the kyai learnt that the farmers were not happy with the price offered to them. Initially, farmers were paid 10 cents for 1 kg Calophyllum fruit, but after processing into biodiesel, the total production cost was too high to make it competitive in the existing fuel market. Due to this situation, the price had been reduced to 6 cents per kilogram. Although, according to the kyai, this price was reached through negotiation with the farmers, some of the latter were disappointed and chose not to collect Calophyllum anymore.[4]

The entrepreneur's engagement with the kyai also gave him access to capital for his business. Within the religious community coordinated by the kyai, they had an *infaq* for technology, a charity to please God without asking anything in return for new technology.[5] The entrepreneur used this capital to fund his laboratory experiments in Calophyllum oil production, biodiesel production and road tests. Calophyllum oil production began with the drying of Calophyllum fruits under the sun, after which oil was extracted from the fruit using a pressing machine and degummed from phospholipids. To transform it into biodiesel, the oil had to pass the process of esterification and transesterification that requires additional chemicals such as HCl and NaOH. The biodiesel product was tested by the entrepreneur and his team using an electricity generator and conducting road tests over a distance of 2470 km.

3.2.1.3. The Bantul and Grobogan actors. One of the actors affected by the central government's policy to develop ESSV was Pertamina, the national oil company. In his visit to Grobogan in February 2007, the Indonesian President promised to give 10 million dollars for the local communities in Grobogan to develop Jatropha-based ESSV. Sastiawan, the ex-manager of Pertamina's Community Development program said that the 10 million were paid by three state-owned enterprises: Pertamina, Rajawali Nusantara Indonesia (RNI) and the national gas company. "As usual, every time the President visits a place, he has to donate to the community. At that time, the directors of these enterprises were there, so Pertamina donated 9.9 million dollars and RNI and the national gas company half million dollars each," said Sastiawan.[6] He explained that initially, the central government wanted to hand over this money to the district government, but in the end, Pertamina was the one that managed the fund. Pertamina allocated 4 million dollars to build a biofuel processing unit, 3.7 million for a Jatropha plantation and 2.1 million to support farmers' communities. According to the officer responsible for ESSVs at the planning and development agency of Grobogan,

[2] Interview with the entrepreneur, October 20, 2010 in Bantul, Yogyakarta.

[3] Interview with Calophyllum pickers February 28, 2012 in Kebumen.

[4] Interview with the kyai, in *Energi* magazine, October 2011.

[5] Interview with the entrepreneur in *Energi* magazine, October 2011. While the entrepreneur preferred to use the term angel investor, individuals who provide capital for start-up companies through *infaq* know the risks of the business and in return for the investment, they get shares of the company.

[6] In *Kompas*, 'Energy Self-sufficient Village Was a Lie?', March 18, 2011.

they could not have managed the 10 million dollars (or any other funds from the central government) "without an additional regulation that justifies it."[7] This situation suggests that the financial shield was not sufficient to provide the space for experiment due to absence of an accompanying legal/institutional shield.

During a field visit to Pertamina's biofuel processing unit in 2010, we found that the ESSV had shifted their energy crop from Jatropha to Calophyllum. Again this situation shows that the financial shield was not sufficient. The actors had to constantly adjust their project according to the local configuration. The President's script for shielding Jatropha-based fuel had been transformed into support for Calophyllum-based fuel in the field. As discussed above, the new Calophyllum-oriented shield had ushered in the entrepreneur from Bantul.

3.2.2. Nurturing: Controversies over protective space practices

3.2.2.1. The Purworejo actors. As part of the nurturing in-scription to ensure learning and networking, the central government supported the project by providing machines, chemicals, training and financial capital for actors in Purworejo. During the de-scription process however, many deviations from the government's script were observed due to inefficient and damaged machines, the absence of a biofuel market, high production costs and finally, the different livelihood situations of the many small farmers who started collecting Calophyllum seeds.

Lasiyah, one of the farmers, started collecting Calophyllum fruits after a worker from Tracon (the firm that supplied processing machinery) persuaded her to sell Calophyllum seeds to him. As a farmer with a small parcel of land to grow her own vegetables and no husband, she expected that selling Calophyllum fruit could give her an additional income during the time when paddy and other vegetables were planted but not ready to be harvested. She described herself as a peasant whose main job was working in other farmers' paddy fields. By supervising six to eight other farm-workers during the paddy harvesting time, she would get an income of around 8 dollars per day.[8] When there was no paddy to be harvested, she worked in other farmers' fields as a labourer to maintain their vegetables.

Cycling together with her to the Calophyllum forest for a day during the fieldwork, the first author learnt that Calophyllum for her was just like any other crop. It gave her access to land she did not have and additional 'harvest' that she could sell. She said that this switch from one crop to another was as easy for her as turning her bicycle from the forest area to the paddy field. Returning from the Calophyllum forest to the paddy field, which took about an hour, she began grinding the paddy with her other colleagues. At 3.30 PM, she called the day off and went home with dry paddy that she put in front of her house. According to Lasiyah, a farmer's decision to become a Calophyllum picker was influenced by their access to land and the different harvest times of paddy, corn, tubers, vegetables and beans.

The learning process of the head of agricultural and forestry agency of Purworejo was visible in the national evaluation meeting on ESSVs in May 2010. He reported that since December 2009 when the Minister of Forestry inaugurated the ESSV project in Purworejo, it was only used once for processing 750 kg of Calophyllum fruit into 60 L of biodiesel.[9] The causes of this non-production, according to him, included damage to the processing unit machines, no capital flow due to the absence of a market, and the high cost of chemicals (e.g. for trans-esterification) needed to produce biofuels. In response to this situation, he expected the central government to subsidize local business units so that their production costs can compete with the fossil fuel price. In addition, the central government should have invested in efforts to optimize the performance of the biofuel processing machines and supervise the production process since people in Patutrejo village where the biofuel processing unit was located were unfamiliar with operating the machines.[10] One of the deputies in the Agricultural and Forestry Agency of Purworejo described his interest with the project as:

> "What we want from the project is to re-operate the biofuel machines that had been abandoned for two years. To achieve this target, we cooperated with the entrepreneur and the local NGO since they had the technical capability and the network to support the operation of ESSV."[11]

According to another central local actor, the trained operator of the biofuel processing unit since 2008, his employment as the operator was highly irregular: often 1 week of work would be followed by a stoppage of 2 months, or a month's work by a year long hiatus. The operator described meeting one of the FORDA scientists who asked him about why the ESSV in Purworejo did not work. He responded by pointing to the lack of initial capital, inefficiency of the processing unit, high price of Calophyllum fruit, and the absence of a Calophyllum fuel market. The operator argued that the scientists made a mistake in the business model of ESSV that was based on optimizing Calophyllum productivity in the laboratory. In the real situation of Patutrejo village, many other things needed to be taken into account such as the cycle between dry and wet seasons (which influences the harvesting time of Calophyllum), quality of the fruits, drying methods and actual machines. Here, the operator is pointing out that the scientists were focussed on getting a 'universal' (national) in-scription right, without considering the specific local conditions that inevitably shape the de-scription process and therefore the actual practice of biofuel production.

According to the operator, from 750 kg Calophyllum fruits that he received from the collectors, he was only able to produce 171 kg kernel, which after the processing resulted in 49.5 L of Calophyllum oil. This number suggests that in order to produce a litre of oil, they required about 15 kg of Calophyllum fruit, which is almost four times higher than that predicted by the scientists' model (in-scription). To produce biofuel, this oil needs to be processed further via esterification (HCl) and transesterification (NaOH). At the beginning of the program,

[7] Interview with the officer of the planning and development agency of Grobogan, October 14, 2010.

[8] We convert all the Indonesian curreny (IDR) to dollar based on the actual rate with 1 USD = 8600 IDR.

[9] Presentation of the head of Agricultural and Forestry Agency of Purworejo, May 6, 2010.

[10] Ibid.

[11] Statement ofthe Agricultural and Forestry Agency of Purworejo elite in the local workshop, April 10, 2012.

the government provided the processing unit with 200 L of methanol that is needed for the transesterification process. After this stock was finished, the operated did not know how to get the new supply. He returned to his initial job as a farmer and sugar producer.

3.2.2.2. The Bantul and Grobogan actors. In 2011, the management team of Grobogan ESSV asked the Bantul entrepreneur to adapt the central government's business model. In the new business model, the entrepreneur made plans to supply biofuel for running base transceiver stations (BTSs), devices that facilitate wireless communication such as for GSM and CDMA between user equipment and telecommunication provider. Based on his market research, he calculated that this captive market had a potential of 43.68 billion litres per year.[12] Unfortunately, cooperation between the entrepreneur, the ESSV cooperative and an energy provider company for BTSs based in Jakarta only lasted for 6 months. The representative of the Grobogan cooperative blamed the entrepreneur for running away from the site without any explanation and for exaggerating the possible benefits,[13] while the entrepreneur claimed that an internal conflict between cooperative members was the reason why he left Grobogan.[14]

3.3. A new inscription

The Coordinating Ministry of Economic Affairs conducted regular meetings for ESSV actors to learn from each other's experience and to carry out networking. In the end of 2011, during one such meeting, the entrepreneur from Bantul was asked by the district government of Purworejo to revitalize the local ESSV. The entrepreneur agreed to support the ESSV, which led to a new (local) ESSV in-scription. This re-inscription was performed by local actors by re-calculating the space inscribed with the central government's ESSV project scripts and attached to biofuel processing machines, Calophyllum forest and local actors. The presence of local actors as being affected by the script implied a recursive relation between the construction of the space and of the actors' activities within that space. We call the ESSV within this new in-scription process as ESSV 2.0 because it was constituted by different actors than the central government-led ESSV in-scription earlier.

3.3.1. Shielding: Setting the new context

To stave off the selection pressure, differently from the standardized approach promoted by the central government, the officer of the district government of Purworejo and the entrepreneur from Bantul created a shield consisting of local actors. This shield was practiced by inviting Watershed Management Center (WMC), Perhutani (state forestry company), Agricultural and Forestry Agency and the village cooperatives to a meeting to lock-in their commitment to support the business strategy proposed by the entrepreneur. The strategy consisted of three phases: (i) to develop a homogeneous business focused on a single market and covering a limited geographical area; (ii) to diversify the business, entering various (energy and non-energy) markets; (iii) to extend geographical coverage to other areas. After succeeding in creating this institutional shield for ESSV 2.0, the entrepreneur constructed the technological shield by bringing in his own machines and two of his workers from Grobogan (the site of his initial operations) to Purworejo, while hiring the same operator as the one who had received training from the central government to run the ESSV project. According to the entrepreneur,

> "Calophyllum contains an undesirable resin that made the esterification process difficult. We could not use the machinery that the government had provided. We needed to modify it. We decided to begin with small capacity, around 200–300 liter of biofuel per day. With such a capacity, we expected to meet the local need. There were local businesses that relied on solar power for their production. The central government did not allocate subsidy to solar for commercial purposes. Thus, we believe that our biofuel could compete with solar in terms of price."

To maintain cash-flow for ESSV 2.0, the entrepreneur relied on his network with the kyai and his connection to the batik industry, which used Calophyllum oil to dye fabric. Therefore, interestingly the entrepreneur and the district government of Purworejo built their shields in ESSV 2.0 by treating themselves not only as designers, but also as users. This combination of being a designer and a user enabled them to create shields with fluid boundaries.

3.4. De-scriptions: ESSV 2.0

The de-scriptions of ESSV 2.0 were performed by the local actors in Purworejo including the district government of Purworejo and the entrepreneur from Bantul. In de-scribing the materials, these local actors were continuously grouping and re-grouping their networks. For instance, the entrepreneur and the district government of Purworejo acted as a collective in front of the other local actors, but when the German Federal Ministry for Economic Cooperation and Development and *Deutsche Gesellschaft für Internationale Zusammenarbeit* covered the Calophyllum initiatives in Purworejo as a case study for climate change mitigation and adaptation, the entrepreneur did not mention any collaboration with the district government.

3.4.1. Shielding: Re-configuration of local actors

Shielding was practiced by the entrepreneur and the district government by reframing the boundaries of the protective space strategically by continually including and excluding actors into and from the ESSV 2.0. This fluid shield manifested clearly in the relationship between the entrepreneur and the Calophyllum pickers. In front of the 'global' actors (e.g. the central government, the German government and NGOs), the entrepreneur represented himself as putting the pickers' welfare as his top priority. However, among actors in the local network, the entrepreneur tried to optimize the ESSV's (and his) profit by reducing the price paid to the pickers,

[12] One of the biggest telecommunication companies in Indonesia had started a program to improve the reliability of their BTSs by using alternative energy that was available locally (Dahono, 2013). The number of BTSs operated by this company was 13,000 and half of them were located in remote areas. Dahono et al. noted that one BTS on average consumed 2000 L of diesel per month.

[13] Interview with the representative of Grobogan cooperative, May 2012.

[14] Interview with the entrepreneur, November 14, 2012.

Table 2
The in-scriptions and de-scriptions of protective space.

	In-scriptions	Objects	De-scriptions
Shielding	Political: The central government staved off regime selection pressures by instructing 15 cabinet ministers, governors and district heads to support biofuel development. Financial and technical: The central government protected the ESSV project by building a biofuel processing unit, by funding first 3 months' operational costs and provided technical training to local actors	The Presidential instruction; the central government's financial and technological support.	Purworejo actors Interpreting the instruction and the machines as an obligation and following the central government's orders. *A Resource shield* constructed using existing Calophyllum trees; job opportunities created using a new crop cycle; the district government of Purworejo planted 20,000 new Calophyllum trunks. Bantul and Purworejo actors Interpreting the instructions as opportunity to generate profit from biofuel businesses. *A Cultural shield* enacted by Bantul actors, by enrolling a kyai into an entrepreneurial network to ensure Calophyllum supply. Bantul and Grobogan actors Interpreting the instructions as obligatory and following the central government's interest. *A Financial shield* constructed when Pertamina was instructed to donate 9.9 million dollars to support ESSV in Grobogan; collaboration with Bantul actors shielded a different space than the one conceptualized by the central government.
Nurturing	Learning: FORDA focused on optimizing the business model. Networking: collaboration between FORDA and Tracon to develop an optimum biofuel machine. Articulating expectations: optimizing biofuel production process.	The standardized business model and machines.	Purworejo actors *Learning:* the pickers learned to calculate the Calophyllum cycle (e.g. its harvests season) and to calculate cost/benefit from picking the fruit; Purworejo's district government learned that there were no biofuel buyers in the area and the production cost was higher than assumed in the central government's business model; the machines operator also learned that the assumptions of the business model did work in practice. Bantul and Grobogan Actors *Learning:* the Grobogan actors learned that farmers in Grobogan were not interested in Jatropha and that they did not have biofuel buyers. *Networking:* the Grobogan actors used this knowledge to build a network with an entrepreneur from Bantul, who agreed to connect them with buyers. *Articulating expectations:* the Grobogan actors expected the Bantul entrepreneur to supply them with Calophyllum fruit and to connect them with biofuel buyers and the Bantul entrepreneur expected to gain profit from their collaboration. This collective ended due to internal conflict.
Empowering	Stretch and transform The central government issued several regulations that promote the supply and utilization of biofuels as alternative fuels, the formation of a National Team for biofuel development, requirements and trading licensing guidance for biofuels as alternative fuels, reduction of income tax and mandatory requirements for biofuel utilization		
New in- and de-scriptions			
Shielding	Institutional: The central government facilitated learning through networking. Local: The officer of the district government of Purworejo and the entrepreneur from Bantul created a shield consisting of local actors.	Biofuel processing unit, peeling machines, Calophyllum forest.	Fluid shields were practiced by reframing the boundaries of the space strategically by including and excluding actors into and from ESSV 2.0.
Nurturing			Learning: the entrepreneur expanded the Calophyllum market to non-energy use after learning that the existing energy market was inadequate to support the production costs of ESSV 2.0; some farmers chose to withdraw their involvement in picking Calophyllum due to uncertainties in price and due to weight loss; the operator dealt with an internal conflict between him and the two other workers. Networking and articulating expectations: the heterogeneous actors realized that despite their mutual connections to the ESSV 2.0, their individual interest might conflict with another related actor's.

Table 2 *(continued)*

In-scriptions	Objects	De-scriptions
Empowering		Applying a localized stretch and transform mechanism (e.g. Perhutani that usually allocated its corporate social responsibility fund for reforestation broadened its funding criteria by including the Calophyllum road test).

> "One critical point for durability of the biofuel business is the production cost. [In this area] people pay 4 dollars for eight hours labour work within which the pickers may collect around 200 kilograms of Calophyllum fruit. If we divide the labour cost with the number of kilograms collected per day, we get a Calophyllum price for 2 cent per kilogram," said the entrepreneur's colleague who was responsible for ESSV 2.0.

This new price was one-fifth of the initial price level offered by the entrepreneur to fruit collectors in 2008. The daily collection numbers reported by the entrepreneur were refuted by one of the pickers, "during the harvest season, I can get 100 kilograms per day, but when it is not the right season, usually I can only collect 15 kilograms."[15]

Apart from re-framing the shield to gain political and financial benefit, the entrepreneur also applied the fluid shields to markets. Instead of only focusing on the energy market, as suggested by the central government's business model, the ESSV 2.0 had expanded its market to the textile industry and to research agencies that needed Calophyllum oil for experiments.

3.4.2. Nurturing: Strengthening the local actors' network

In nurturing the space composed by a network of Calophyllum suppliers in Purworejo district, the entrepreneur started to re-configure his network. He brought in his peeling machine, which he had used earlier in Grobogan to separate oil from Calophyllum pulp, to Purworejo along with two biofuel workers from Grobogan. For the operational costs, he relied on *infaq* for technology, his personal resources and the 'market' demand from research institutes and batik industries. According to the operator of the biofuel processing unit, FORDA bought Calophyllum from Purworejo to be used in their car as part of their tests and an agency running a Calophyllum nursery wanted to buy fruits from them to be used as seeds. Batik industries bought Calophyllum oil not for energy purpose but rather to dye batik fabric. However, even together, these markets were not big or stable enough for the biofuel processing unit to survive in the long-run: demand from research agencies was uncertain, while demand from the batik industry was only 75 L per month (in contrast to the production capacity of 400 L per day).

To promote the business, the entrepreneur and his partners held a Calophyllum road test in March 2012, with Perhutani's corporate social responsibility unit as the sponsor. The road test succeeded in creating a ceremonial event in each district through which the car passed and in attracting the national government's attention. Two weeks after the road test, the entrepreneur's company, Cahaya Khatulistiwa, *Relung* (an environmental NGO) and the Agricultural and Forestry Agency of Purworejo received an invitation from the Directorate General of Renewable Energy and Energy Conservation to discuss the continuation of the Biofuel Self-sufficient Villages program in Jakarta. In this meeting, the entrepreneur criticized the government's approach to the program as being unrealistic and asked the national government, through the representative of the Coordinating Ministry of Economic Affairs, to place a moratorium on the program. He wanted the government (and its scientists) to admit their miscalculation of the energy crop's potential, the available market for biofuels and to leave people in the districts or villages unsupported in their efforts to make some use of the remains of the program. Despite his critique of the government's program, he was acutely aware that the success of his business, which was a successor to the ESSV program, was dependent on the government's continued interest in biofuels and self-sufficient villages. Therefore, at the same time as criticizing the government's program, he attended meetings within the context of the program and hoped to get national government funds to revitalize the biofuel processing unit that he used to run his business on.

In response to the entrepreneur's observations about the government's mistakes, the representative of the Directorate General of Renewable Energy and Energy Conservation said that what happened in the field was not the government's mistake but rather an unexpected result of the high production cost. The business model adopted by the government for the Calophyllum ESSV program included profit and competitive price calculations based on a production efficiency that was unrealizable in practice. He also rejected the claim that the government had acted irresponsibly since the government had always facilitated dialogue between national and local actors by organizing various stakeholder meetings. With regards to the situation of Purworejo, he suggested that they shift the local market to Calophyllum plant oil rather than Calopyllum biodiesel. To support this new direction, the national government was willing to support them by providing a suitable cook-stove for Calophyllum oil.

The central government's latest suggestion to in-scribe the ESSV as a project to provide rural households with cooking oil was not compatible with the interests of Purworejo's district government and of the entrepreneur to produce biofuel for small and medium enterprises. The entrepreneur had also wanted the Calophyllum for non-energy markets such as batik printing.

In the meanwhile, in the de-scription process beyond the control of the entrepreneur and the government, some farmers had chosen to withdraw their involvement in picking Calophyllum due to delays in payment for the fruit they collected, the falling price and due to weight loss of the fruit in storage. And the trained operator in Patutrejo had to deal with an internal conflict between him and the two workers brought in by the entrepreneur from Grabogan.

[15] Workshop in Purworejo, April 10, 2012.

These disparate practices show that the heterogeneous set of actors involved in ESSV 2.0 enacted the project differently, and their own individual interests sometimes came in conflict with those of another related actor.

3.4.3. Empowering: Organizing controversies

The entrepreneur empowered the ESSV 2.0 using a localized stretch and transform mechanism. The Agricultural and Forestry Agency that initially only dealt with crops and lands had to re-frame its roles to include energy and Perhutani that usually allocated its corporate social responsibility fund for reforestation widened their funding criteria by including the Calophyllum road test. The presence of ESSV in Purworejo with its complex problems also stimulated more meetings for coordination between the entrepreneur, operator of the ESSV machine, the village apparatus, Agricultural and Forestry Agency, NGOs, the Watershed Management Centre (WMC) and Perhutani.

In mobilizing Calophyllum activities in Purworejo and other areas, the entrepreneur's firm Cahaya Khatulistiwa worked together with Relung, an NGO that collaborated in the road test and a second NGO named Institute for Forest and Environment. Both NGOs were active in the field of promoting and supporting community-based initiatives in natural resources and sustainable livelihoods. In addition, the entrepreneur worked with a WMC (in Southern Java), which became a hub for bringing various actors together such as the local government of Purworejo, Perhutani of Kedu Selatan and Relung. This role for the WMC was formalized through a decree stating its support to develop Calophyllum by identifying and registering land available for Calophyllum plantations and to facilitate communication between different actors. These activities to stretch and transform the local configuration implicated the entrepreneur as a hybrid user-designer, who set the script and was also now playing an active role in de-scribing it.

4. Summary and conclusions

Through a study of in-scription and de-scription processes in protective spaces, we have documented how the design of Indonesia's biofuel policies has shaped the socio-technical configuration of two experimental local projects. A summary of our results is provided in Table 2.

The notions of in-scription and de-scription were useful to capture non-linearity between design of the protective space and the actual socio-technical configurations that were materialized. This non-linearity emerged through changes in direction between in-scription and de-scription in processes of shielding, nurturing (learning, networking and articulating expectations) and empowering and also through changes in the actors' individual interests (cf. Geels and Raven, 2006). Our analysis shows that at the beginning of the projects, a diverse set of actors supported the central government's policies on biofuel development. In this period, actors' heterogeneous interests were largely invisible because the different elements (e.g. political and financial support) of the projects were working together as expected by these actors. However, when the financial support ended and the local biofuel buyers failed to arrive on the scene, heterogeneity of the actors' interest became overt (e.g. the pickers saw Calophyllum as a cash-crop and not as part of solving their or the nation's energy problems in accordance with the central government and the entrepreneur treated Calophyllum strictly as a business opportunity). Thus the practice of the projects was driven not by a shared interest to solve the energy crisis, as expected and in-scripted by the central government, but rather by the benefits afforded by the projects to satisfy the actors' individual interests in and through the de-scription process.

Secondly, the combination between protective space and script allowed a close examination of actors' agency and power relations between them. Our analysis showed that each actor interprets the projects according to their interests and resources or in short, their relational configuration. We showed how actors with more resources (e.g. the central government, the entrepreneur) were generally able to mobilize actors with fewer resources (e.g. the pickers) (cf. Star, 1990), but the other way around was much more difficult. Additionally, the entrepreneur used the asymmetrical relations between him and local actors to mobilize support from the central government and international organizations. Finally, the entrepreneur's ambivalence about being part of the central government's network and of the local supplier network allowed him to reinforce and sustain his relational configuration (cf. Singleton and Michael, 1993; Casper and Clarke, 1998). These findings show that actors often coordinated through misunderstanding, which was facilitated by ambivalence and asymmetry in relations with others and with the biofuel project (cf. Stark, 2009).

Thirdly, in terms of protective space, our analysis shows that adopting a stretch and transform strategy from the beginning does not necessarily result in successful deployment and growth of radical innovations. This is because stretching may be limited to a single domain such as the national regulatory environment in the ESSV program. In particular, biofuel projects on the local level continued to face a more hostile selection environment, and the program did not succeed in stretching and transforming the local environments. Hence, our study shows that regime transformations through stretch-and-transform strategies really needs to be a multi-dimensional (Smith and Raven, 2012) and multi-scalar process (Coenen et al., 2012).

Last but not the least, the framework allowed us to have a better understanding on controversies in practice. Our analysis showed that controversies emerged through two trajectories. First, controversies emerged through the central government's inability to stretch-and-transform the local environment. These controversies were productive in stimulating the emergence of new local initiatives. Second, controversies emerged through operating the radical innovation in a non-stretched environment. The entrepreneur tried to compete in the market by lowering Calophyllum buying price from the pickers. This strategy stimulated the emergence of local controversies between the entrepreneur and the pickers. This last remark calls for further investigation into different types of controversies and how they may be managed to facilitate sustainability transitions.

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References

Akrich, M., 1992. The de-scription of technical objects. In: Bijker, W.E., Law, J. (Eds.), Shaping Technology—Building Society: Studies in Sociotechnical Change. MIT Press, Cambridge, Mass, pp. 205–224.

Amir, S., Nurlaila, I., Yuliar, S., 2008. Cultivating energy, reducing poverty: biofuel development in an Indonesian village. Perspect. Glob. Dev. Tech. 7 (2), 113–132.

Boon, W.P., Moors, E.H., Meijer, A.J., 2014. Exploring dynamics and strategies of niche protection. Res. Policy 43 (4), 792–803.

Brown, S.D., 2002. Michel Serres. Theory Cult. Soc. 19 (3), 1–27.

Bustomi, S., Lisnawati, Y., Supriadi, Darwiati, W., 2010. Ecosystem Analysis for Calophyllum-based Energy Self-sufficient Village. Report of the Research and Technology Incentive Program.

Callon, M., 1986. Some elements of a sociology of translation: domestication of the scallops and the fishermen of St. Brieuc Bay. Power, action, and belief: a new sociol. of knowl. 32, 196–223.

Casper, M.J., Clarke, A.E., 1998. Making the pap smear into the right tool for the job cervical cancer screening in the USA, circa 1940–95. Soc. Stud. Sci. 28 (2), 255–290.

Coenen, L., Benneworth, P., Truffer, B., 2012. Toward a spatial perspective on sustainability transitions. Res. Policy 41 (6), 968–979.

Cornwall, A., Brock, K., 2005. What do buzzwords do for development policy? A critical look at 'participation', 'empowerment' and 'poverty reduction'. Third World Q. 26 (7), 1043–1060.

Dahono, P.A., 2013. Microgrid Applica-ons in Indonesian Telcom Industries. Presented in Santiago 2013 Symposium on Microgrids, September 12th.

FORDA, 2008. *Nyamplung (Calophyllum inophyllum L.) sumber energi biofuel yang potensial*. FORDA Press, Jakarta.

Geels, F.W., 2011. The multi-level perspective on sustainability transitions: responses to seven criticisms. Environ. Innovation and Societal Transitions 1 (1), 24–40.

Geels, F., Raven, R., 2006. Non-linearity and expectations in niche-development trajectories: ups and downs in Dutch biogas development (1973–2003). Tech. Anal. Strat. Manag. 18 (3-4), 375–392.

IISD, 2010. Fossil fuels—at what cost? Government support for upstream oil and gas activities in Indonesia.

Joerges, B., 1999. Do politics have artefacts? Soc. Stud. Sci. 29 (3), 411–431.

Jupesta, J., 2012. Modeling technological changes in the biofuel production system in Indonesia. Appl. Energy 90 (1), 211–217.

Kemp, R., 1994. Technology and the transition to environmental sustainability: the problem of technological regime shifts. Futures 26 (10), 1023–1046.

Kemp, R., Schot, J., Hoogma, R., 1998. Regime shifts to sustainability through processes of niche formation: the approach of strategic niche management. Tech. Anal. Strat. Manag. 10 (2), 175–198.

Kern, F., Smith, A., Shaw, C., Raven, R., Verhees, B., 2014. From laggard to leader: explaining offshore wind developments in the UK. Energ. Policy 69, 635–646.

Latour, B., 1992. Where are the missing masses? The sociology of a few mundane artifacts. In: Bijker, W.E., Law, J. (Eds.), Shaping Technology—Building Society: Studies in Sociotechnical Change. MIT Press, Cambridge, Mass, pp. 225–258.

Levidow, L., Pimbert, M., Vanloqueren, G., 2014. Agroecological research: Conforming—or transforming the dominant agro-food regime? Agroecol. Sustain. Food Syst. 38 (10), 1127–1155.

MEMR, 2007. Indonesia's Experience on Biofuel Development (presentation in the International Biofuel Conference, Brussels, July 5th 2007).

Raven, R.P., Verbong, G.P., Schilpzand, W.F., Witkamp, M.J., 2011. Translation mechanisms in socio-technical niches: a case study of Dutch river management. Tech. Anal. Strat. Manag. 23 (10), 1063–1078.

Raven, R., Kern, F., Verhees, B., Smith, A., 2015. Niche construction and empowerment through socio-political work. A meta-analysis of six low-carbon technology cases. Environmental Innovation and Societal Transitions http://dx.doi.org/10.1016/j.eist.2015.02.002 (in press).

Rip, A., Kemp, R., 1998. Technological Change. Battelle Press, pp. 327–399.

Schot, J., Geels, F.W., 2008. Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy. Tech. Anal. Strat. Manag. 20 (5), 537–554.

Singleton, V., Michael, M., 1993. Actor-networks and ambivalence: general practitioners in the UK cervical screening programme. Soc. Stud. Sci. 23 (2), 227–264.

Smith, A., Raven, R., 2012. What is protective space? Reconsidering niches in transitions to sustainability. Res. Policy 41 (6), 1025–1036.

Smith, A., Kern, F., Raven, R., Verhees, B., 2014. Spaces for sustainable innovation: solar photovoltaic electricity in the UK. Technol. Forecast. Soc. Chang. 81, 115–130.

Star, S.L., 1990. Power, technology and the phenomenology of conventions: on being allergic to onions. Sociol. Rev. 38 (S1), 26–56.

Star, S.L., Griesemer, J.R., 1989. Institutional ecology, translations and boundary objects: amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. Soc. Stud. Sci. 19 (3), 387–420.

Stark, D., 2009. The Sense of Dissonance. Accounts of Worth in Economic Life. Princeton University Press, Princeton and Oxford.

Sudradjat, 2008. Pusat Penelitian dan Pengembangan Hasil Hutan telah melaksanakan penelitian pembuatan biodiesel dari biji nyamplung 2005-2008. Bogor: research report.

Verhees, B., Raven, R., Veraart, F., Smith, A., Kern, F., 2013. The development of solar PV in The Netherlands: a case of survival in unfriendly contexts. Renew. Sust. Energ. Rev. 19, 275–289.

Verhees, B., Raven, R., Kern, F., Smith, A., 2015. The role of policy in shielding, nurturing and enabling offshore wind in The Netherlands 1973–2013. Renew. Sust. Energ. Rev. 47, 816–829.

Yin, R.K., 2009. Case Study Research: Design and Methods. 4th ed. Sage, California.

Yudhoyono, S.B., 2006. (Post-crisis) New Deal and Bioenergy Actions Plan: upaya percepatan dan pengurangan kemiskinan dan pengangguran (Losari, July 1, 2006.).

Yusgiantoro, P., 2007. Biofuel Development in Indonesia. Strategic Partnership on Biomass Workshop, Jakarta, February 5, 2007.

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