Transition in action : non-linearity, multiplicity, materiality in Indonesian biofuel villages

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PROEFSCHRIFT

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door

Yuti Ariani Fatimah
geboren te Bandung, Indonesië

Dit proefschrift is goedgekeurd door de promotoren en de samenstelling van de promotiecommissie is als volgt:

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The road to hell is paved with good intentions

Anonym

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[1] Alice in Carroll, *Alice's Adventures in Wonderland*

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1. Introduction

"We have to launch a New Deal as a means to create jobs and to rescue the suffering from the crisis, which is partially caused by the wrong approach, prescriptions and policies, including the weakening of the purchasing power because of the rise of fossil fuel price. We have to bring hope to our people, and free them from fear and insecurity."

-- The Indonesian President (Losari, July 1st, 2006)

1.1 Background of the Study

In the mid 2000s, there was widespread interest among Indonesian scientists, national level bureaucrats and local entrepreneurs to develop a small scale local crop-based biofuel industry. To draw up a conceptual approach and obtain commitments from various stakeholders, the President convened a special cabinet meeting where he delivered the statement cited above to contextualize biofuel development as part of a special program called the New Deal. In the context of biofuel development, the New Deal was translated into an objective to transform millions of hectares of 'non-productive' land into energy crops through which to create 3.6 million new jobs, reduce the poverty rate by 16 per cent and lower oil imports by US$ 5 billion per year (Dillon et al., 2008). Yet, nine years after the President mobilized bureaucrats, politicians, scientists and farmers to develop formal regulations and by offering subsidies to support biofuels, the development of small-scale biofuel industry has largely come to a halt (e.g. Amir, 2008; Vel, 2014). This dissertation aims to understand why most small-scale biofuel projects in Indonesia have stalled despite many forms of political and financial support. By asking this question, this study seeks to contribute to transition studies, especially by focusing on a transition in action, with its multiple contingencies, instead of a completed historical transition.

In studying a completed historical transition, boundaries of a societal system can be well-defined while issues of non-linearity, multiplicity and materiality may either be simplified or overlooked. In this well-defined boundary, the issue of non-linearity is addressed via articulating differences between an initial conceptualization of a new technology and its implementation due to learning processes and/or external developments (Geels & Raven, 2006). The issues of multiplicity and materiality are being implicitly addressed respectively through the ideas of 'hopeful monstrosities' (Mokyr, 1990; Geels, 2002; Raven & Geels, 2010) and of technology as a heterogeneous 'configuration that work' (Rip & Kemp, 1998:330; Geels, 2005). Multiplicity

implied in hopeful monstrosities work through promises and crude performances of new technologies, which afford them to engage with various actors and to develop to an unexpected trajectory. Whereas the idea of a configuration that works includes materiality in the form of alignment between technical form and social function in shaping the nature of technological artifact (Van de Poel, 1998).

In contrast, transitions in action operate in settings where boundaries between technology and society are controversial due to disputes among actors in determining the constituent elements of the technology and its social context (Callon, 1998). Multiplicity is resulted from simultaneous enactment of an object or a governmental project in different practices that overlap in many and unpredictable ways. Distribution of degree of uncertainty, which in historical transition centers in the new technologies, is distributed to related actors, including non-human actors. Rather than treating agency as human's intentional action to influence a course of events, transitions in action define agency as the *effects* of actors' relational actions (Callon & Law, 1995). This ontological position is quite different than scholars within the moral philosophy tradition, which focuses on the *cause* of actions such as reasons, desires and human's intentions (Waelbers, 2011).

By elaborating agency through its effects instead of its cause, I am able to extend the articulation of agency to non human actors. It suggests that agency do not presence, but rather emerge through interactions between human and non-human actors. This conceptualization requires the analyst to shift the issue of agency from being a 'matter of fact', as something that is unproblematic and given (e.g. in describing actors' ability to take action to have a transition from horse-drawn carriages to automobiles instead of asking how the transition effects the socio-economical situation of a country: Geels, 2005), to agency as a 'matter of concern', as something that becomes visible in the process of definition of its own dynamic boundaries in relation to its context (e.g. in describing the change from horse-drawn carriages to automobiles as a non-linear one entailing many setbacks, multiple interlinked technological choices, hybridizations and internal disputes about what constitutes as proper land transport in a context of industrial modernization) (Latour, 2005).

As a 'matter of concern', transitions in action is articulated by focusing on the connection between the multiple contexts of a socio-technical change of what are being observed and the epistemological approach adopted by the analyst to value the socio-technical change. This perspective shares similarities with Voβ and Kemp (2006) and Bos and Grin (2008), which focus on reflexive governance, especially with the issue of co-steering between the object of governance and the subject. Transitions in action extend this reflexivity by performing an

experimental approach in transition, in which the subjects of observation have plural voices through different frameworks adopted in the dissertation.

This dissertation provides an interpretation of transitions in action by following small-scale biofuel projects from their conceptualization in scientists' laboratories and national policy makers' offices to their materialization in district government's offices and on farmers' land, between 2002 and 2012. For scientists, biofuels were destined to play an important role for the national energy sector since they were the only 'renewable' resource that could be converted in a relatively straightforward way into transport fuels and because Indonesia had many potential biofuel crops (Interview A, 2002). However, when the scientists attempted to enroll the national policy makers into supporting biofuel development, they were confronted with a different set of justifications. These included performance of the energy crops to produce oil and also to address poverty and unemployment issues, which in 2005 was the central government's main concern (Amir et al., 2008). For the central government, the rise of world oil price and the national socio-political conditions of widespread (energy) poverty and unemployment provided them with a golden opportunity to include biofuel development in their national energy plan. And so, networks between scientists and policy makers emerged as a matter of opportunity for both of them (Stengers, 2011). An alliance with the policy makers allowed the scientists to access more resources to develop their research on 'renewable' energy, while it allowed the policy makers to propose a solution to the national energy crisis and socio-political problematizations. Yet this emergent network did not have well-established or stable boundaries, which meant that all its constituent elements changed in the course of their interactions with each other and with a changing context (Callon & Law, 1995; Callon & Law, 1997). Studying the emergent network (as part of a transition in action) also reveals that heterogeneous actors such as scientists and the central government administrators relate to different values and enacted biofuels based on what matters for them.

In general, prior research has elaborated actors' diversity by focusing on their strategies and their resources in sustainability transitions (e.g. Penna and Geels, 2012; Quitzau et al., 2012; Schuitmaker, 2012). While this focus allows them to expose a range of motivations behind actions, their explanations of social change are nevertheless bounded by the parameters provided by system stability and *a priori* alignment between system components. Jørgensen (2012) argues that the heuristic devices provided by the multilevel perspective (Rip & Kemp, 1998; Geels, 2002), by tending to favor the position of the entrepreneur in creating innovations in niches, ends up promoting a managerial perspective on social change in its advice to public authorities. Rather than providing another managerial perspective on transitions, this dissertation (by

adopting transition in action approach) tries to provide insights into the dynamics of innovation and social relations by emphasizing diversity in actors' agency (e.g. by including non-human actors) and elaborate differences in (asymmetric) power relations among them. This emphasize is executed by conducting case studies of four small-scale biofuel projects and by performing different frameworks to highlight different things of the case. It suggests difference between historical transition and transition in action lies not only on the cases but also on the methodology to understand the cases.

Transition in action approach is not performed toward integration of having a singular or a convergence definition, but rather it is performed through experimentation of having different and sometimes conflicting ways of understanding agency and power. The experimental approach is taken due to absence of a well-defined boundary in an ongoing transition and thus, calls for an experimental approach to try different frameworks to understand ongoing transition. It is through experimenting with these different and conflicting frameworks, the object of transition studies can be analyzed and later on, be understood. This understanding emerges as an effect of applying a particular framework to a case and to see how the case is used to build a theory based on how it fits or does not fit (Eisenhardt & Graebner, 2007) and also as an effect of frictions of applying these multiple frameworks (Mol, 2010). An economic explanation (e.g. Chapter 3) on how power is performed through 'regime' of calculating interests and of optimizing actions for instance, conflict a material explanation (e.g. Chapter 4) on how trees perform power through a 'regime' of growing and physically changing. Strength of this dissertation lies on the experimentation of exploring the possibility to turn contrasting standpoints of agency and power among different frameworks into a 'coherent account' of allowing different conclusions to be compared and thus, to be connected (Stengers, 2011:53).

This dissertation shows that agency and power is performed in diverse ways through the creation of a set of actions. This set is assembled by interesting, enrolling and aligning a number of different (heterogeneous) participants that can be human or nonhuman (Latour 1990). The idea of a set of actions is adopted in the empirical chapters through notions such as inscription and description (Chapter 2), enactment (Chapter 3), episodes (Chapter 4) and entanglement (Chapter 5). These notions are used to separate one set of actions such as a government-led intervention with another set of actions such as initiatives led by the same government actors at different times or by other actors with different interests or values. By approaching transition as a series of these sets of actions, the analyst is able to slowing down the analytical process and to show plurality, power struggle and frictions between these actors and between the same actors at different times. For instance, in early 2000 to mid-2000, researchers mobilized biofuel issues by

attaching biofuel development to poverty and unemployment issues. This engagement transformed both the characteristic of renewable energy research and the national programs on poverty and unemployment. The researchers started studying the viability/potential of their program for poverty reduction and job creation, while the government designed a policy that is based on laboratory experiments. As a new set of actions became larger by enrolling other actors and by aligning with their interests and passions, it became 'more and more real' or more powerful (see Latour 1990).

The illustration suggests that power is performed by making other actors to follow a specific script of developing biofuel to support poverty alleviation and job creation. Yet in order to maintain its power, actors within a set of actions have to maintain participatory of their members from leaving due to being attracted by competing anti-programs of actions. If actors end up leaving a program, by joining other anti-programs (new or existing), it becomes less real, less durable and less powerful. By adopting such an understanding of power and agency, I am able to explain why most small-scale biofuel initiatives in Indonesia stalled despite financial and political support from the central government. I argue that as a series of sets of actions, small-scale biofuel projects in Indonesia stalled due to absence of adequate strategies in the programs to attract new actors and eventually to keep existing participants from exiting by participating in new programs. The biofuel projects did not have enough power to lock actors into following the projects' set of actions. The project, however, succeed in creating a window of opportunity for a local entrepreneur to develop an energy crop-based business, which main customer was non-energy market.

1.2 Agency and power in Transition Studies

The literature on sustainability transitions is marked by a strong influence from quasi-evolutionary theory that conceptualizes technological change as a sequence of variation and selection processes (e.g. Rip, 1992; Schot, 1992). These processes are aligned to such an extent that they allow the emergence and institutionalization of new rules and routines (Rip, 2012). These routines are embedded in a complex set of technical practices, knowledge bases, corporate organization and material infrastructure (Rip and Kemp, 1998). To understand and analyze socio-technical transitions, scholars (e.g. Kemp, 1994; Rip and Kemp, 1998; Geels, 2002; 2005 among others) introduced a Multi-Level Perspective (MLP) that views transitions as interplay of developments at three analytical levels. Niches are protected spaces that enable the buildup of the momentum of radical innovations in the context of harsh selection environments; socio-technical regimes refer to embedded rules and routines in practices and material infrastructure

that developed around dominant technologies and organizations; and socio-technical landscape refers to the external context that provides the backdrop of niche-regime interactions. Landscape processes can destabilize the regime and create a window opportunity for niche innovations, but can also contribute to stabilizing the existing regime (Geels, 2002). Interactions between these levels are seen as the outcome of interplay between actions limited by routines and how these actions afford change within the routines (Geels and Schot, 2007).

Smith et al. (2005) criticize the multilevel perspective as having a tendency to be "too descriptive and structural, leaving room for greater analysis of agency as a means to more informed, deliberate and effective processes of regime transformation" (p. 1492). In response to this criticism, Geels and Schot (2007) argue that multi-level perspective operates on assumptions that actors exercise their agency by acting strategically. However, in their attempts to optimize their actions, they are bounded by routines and rules as well as by their cognitive capabilities and time. These structural factors and individual constraints limit actors' activities while directing these actors to do new things in specific ways. Further, agency in transitions is considered to be determined by "prior events, selection environments as given and the criteria for success as unequivocal" (Garud and Gehman, 2012:984). Geels (2011:29) argues that MLP "is shot through which agency," primarily through dynamics of social groups that steer transition trajectories and enact 'multi-level alignments'. Shove and Walker (2010) argue that agency in the MLP is understood as 'global', which remains above and beyond actors' everyday activities/practices, and therefore leaves little room for elaborating continuous negotiations between multiple relations that may not necessarily hierarchical (see also Smith, 2007; Elzen et al., 2012; Jørgensen, 2012).

Similarly, Farla et al. (2012) have argued that the focus on understanding transitions as unfolding at the global or systems level may have come at the expense of more agency-sensitive analyses. In recent work, some studies have attempted to address this criticism by providing accounts of how individual actors' strategies, resources and organizations affect the overall system and trigger transformation processes. For example, Penna and Geels (2012) focus on actors in the US car industry, users' associations, civil society groups and policy makers to reduce car emissions to get cleaner air. Their research shows how actors accumulate resources through political contacts and broad information campaigns. Another example comes from Quitzau et al. (2012) who highlight the importance of including niche analysis for planning in local development in addition to niche analysis for technology development that have been articulated quite thoroughly in the transition literature.

Despite allowing a closer look on heterogeneity in actors' strategies and their effects on the transformation processes, these recent analyses are wedded to identifying potential change resulting from innovations per se and not on how these innovations afford side effects associated with the process. The latter side effects and the place of technological innovation therein, are amply studied in development studies. For example, Ferguson and Lohmann (1994) shows that (failures of) innovative projects to increase agriculture productivity in Lesotho help maintain the presence of international agencies in the country, by providing the justification for more developmental projects with better plans and organization. The projects are thus caught up in a process of continual reconfiguration of promises to increase agriculture productivity and of justifying international NGOs presence in the area. These innovation projects are not ('sustainable') ends in themselves, but rather are means to maintaining the interests of international NGOs and their presence in developing countries.

Work on agency in transitions is intimately related to the issue of power (Smith et al. 2005), especially if power is viewed as asymmetrically structured agency (Stirling 2014; Heller and Evans 2010). For instance, Shove and Walker (2007), Kern and Smith (2008) and Smith and Stirling (2008) highlight that transition literature, and especially the writings on transition management, give inadequate attention to power and politics. Other scholars also question democratic legitimacy of the technocratic mode of governance adopted in transition management (e.g. Hendriks, 2009; Hendriks & Grin, 2007) and the apolitical stand taken by transition scholars on sustainability discourses (Smith & Stirling, 2008). Shove and Walker (2008) go further by claiming that transition management obscures the contested matters of boundary making and definitional power (cited in Avelino, 2011). Definitional power refers to the epistemological significance of researchers to favor one particular sustainable scenario over the others (Avelino, 2011). Therefore, Avelino proposes to critically investigate the role of researchers in framing transition stories.

This dissertation responses to the above mentioned critiques by adopting multiple frameworks. These frameworks create various narratives, through which transition in action is being assessed by different values. The current framework developed in Transition Studies for instance, concern about the present of heuristic device to guide the topic if transitions into a particular direction (e.g. Geels, 2011), whereas framework developed in Development Studies is more concern about the issue of inclusiveness and power relation among actors. Intersection between these studies is done not by finding an encompassing synthesis but rather by elaborating the unexpected that emerges through frictions and contrast.

1.3 Transition in Action

Explicit attention to continuous tensions in innovations is the main focus of transition in action. It is built on relationism, a non-essentialist ontology that assumes identity, preferences and interests of individual actors as fluid and constituted by a web of relations and ongoing interactions (Geels, 2010 on relationism). Actors' interests are constituted by continual reconfiguration of the web of interactions in which they are involved (Callon, 1998). This perspective draws insight from actor-network theory and more particularly, on the issues of agency and power in transition. I build my transition in action framework upon existing actor-network theory on agency and power, described in Section 1.3.1 and prior studies that combine actor-network theory and transition studies in Section 1.3.2.

1.3.1 Actor-Network Theory and the Issue of Agency and Power

Actor-network theory (ANT) was originally developed by French sociologist of science Michel Callon (1986) and Bruno Latour (1987) as an approach that treat realities as a continuously generated effect of webs of relations (Law, 2009). ANT studies investigate webs of relations of human and non-human actors and practices that carry them. This web of relations means to place social action not as a result of actors' intentionality but rather as works of nets of human and non-human actors (Latour, 2005; Law, 2009). It resists a priori categorizations and allows the actors to have some room to express themselves, including expressing their multiple identities, affiliations and order (Latour, 2005; Tsing, 2010).

The theory rests in assumptions of distributed agency. It suggests action as shared among various actors so that the prime mover of an action becomes a new, distributed and nested series of practices (Latour, 1999). Action is an emergent effect created by interactions between heterogeneous actors that allow these actors to do new things (Callon and Law, 1995). In actor-network theory, the object of study is not so much to explain, but to deconstruct the subject (Law, 1991). Success of an inventor such as Louis Pasteur is seen as an effect of a set of alliances of heterogeneous materials and not so much as an effect of Pasteur's ability to innovate. This theory tries to refute the heroic of agency by proposing that heroes, actors that are able to create a new line of program, are made up of heterogeneous networks. For instance, the emergent effect for disabling buses and thus, poor people and blacks, who normally uses them to enter Long Island beaches was not only shaped by the designer's discriminative politics to build low bridges (Winner, 1986), but it was also shaped by the webs of relations of the designer (e.g., Moses' position as a big player in regional development planning) and of the bridges (e.g., construction standards, national building culture) (Joerges, 1999).

This connects with the second point of this dissertation, power. Latour (1984) describes power as performed through a paradox. When an actor has power, *in potentia*, nothing happens, but when an actor exerts power, *in actu*, it is others that perform the actions. This conceptualization of power counts initial force as similar as any other and it can stop at any time depending on the action of the actor next in the chain of relations (Latour, 1986). It suggests obedience of actors to follow a particular message lies not on mastery of a powerful actor but rather on fluidity of the message to accommodate heterogeneous interests (Donovan, 2014). This means that amount of power is determined not according to the power someone or something has but rather to its ability to afford others to follow a particular message. In this relational perspective, asymmetry of power is articulated through imbalance between mobilizing others and being mobilized. This conceptualization allows non-human actors to be treated symmetrically as human actors since power is not determined on (human's) intention but rather on its effect. Latour (1990) declares that 'technology is society made durable', meaning stability is mainly achieved through techniques, artifacts and other non-humans actors. Also natural forces like earthquake, gravity and tsunamis are capable of making others, both human and non-human actors, to do or not to do things (Passoth et al., 2012) and therefore, are considered as exerting power.

1.3.2 Actor-Network Theory in Transition Literature

In the transition literature, Rip and Kemp (1998) and Geels and Schot (2007) draw on actor-network theory notions such as heterogeneous configuration, linkages and alignment to articulate recursive relations between social and technical elements of innovation. These scholars incorporate these notions in an evolutionary perspective. This perspective conceptualizes agency and power in terms of structuration between niche and regime. The concept of structuration suggests that structures provide rules and resources for actors and actors are knowledgeable agents who actively draw upon rules in concrete interactions, which allow them to tailor the structure (Giddens, 1984). Geels (2005) argues that agents' concrete interactions constitute a dynamic stability, which he calls socio-technical regimes. Despite this inspiration, Geels (2010) suggests that scholars working on multi-level perspective have not actively pursued further crossovers with actor-network theory due to difference in their ontologies of having levels (MLP) and of being flat (ANT).

The potential of actor-network theory to conceptualize innovations in-the-making has also been mobilized in strategic niche management (e.g., Raven et al., 2011) and transition governance (e.g., Grin, 2006; Smith & Stirling, 2007; Bos & Grin, 2008). Raven et al. combine strategic niche management and the notion of translation (Callon, 1986) to elaborate actors'

agency in steering a sustainable innovation. This combination allows them to articulate tensions between actors protecting their initial interest in developing radical innovation on the one hand and including local actors in the decision making process on the other hand, which might come at the expense of the initial radical objective. In this conceptualization, agency is operated through a web of relations where global and local niche actors are not simply resisting or accepting the initial objective but rather it tries to translate the innovation and modify it to serve their interests.

While not adopting the same notion as Raven et al. (2011), Smith and Stirling (2007) and Bos and Grin (2008) also incorporate actor-network theory in transition through elaborating on the tensions between contrasting perspectives or values. In developing an idea about socio-technical governance, Smith and Stirling develop a reflexive governance framework that consists of governance from the outside, i.e. governance in an ideal world by adopting the right question and the best method, and governance from the inside, i.e. governance that is operated through reflecting on actors' differences and their complex negotiations, which reconstruct the system itself. Power is applied through actors' performances to follow governance from the outside, through which these performances allow the emergence of agency. Bos and Grin address the issue of reflexive governance through what they call reflexive modernization, an approach that is performed by working on action as well as structure at the same time. In developing reflexive modernization, they interpret Latour's (2003) re-modernization as fulfilling its own prophecy since it allows a prescriptive master-narrative to shield actors of a project from the dominant regime. Bos and Grin see this re-modernization as giving too much power to the master-narrative and propose a reflexive modernization that works by changing both structure, via performing modernization and actions, via dealing with risk and unexpected outcomes.

Intersection between transition studies and actor-network theory also appears in the work of Jørgensen (2012) who draws on insight from the multi-level perspective and actor-network theory to build the arenas of development approach (also see Jørgensen and Sørensen, 1999). This approach focuses on the temporary and actor-dependent character of their web of relations which are maintained and compromised through actors' activities in shaping the development process. It highlights network configurations, inclusion and exclusion mechanisms and framing processes. The approach takes outside in a flat ontology that denies pre-classifications of social structures and institutions including a priori classification of levels. As Latour (1999), the arena of development approach assumes agency as distributed among involved actors.

Elzen et al. (2012), Diaz et al. (2013) and Maassen (2012) also address the issue of classification in transition by arguing that institutions, techniques and human actors belong to both niches and regimes (or other spaces for that matter). Using the concepts of anchorage and hybrid forums, Elzen et al. are able to outline a different type of aggregation which goes beyond a vertical empowerment of a niche. Diaz et al. (2013) adopt anchorage from Elzen et al. (2012) to show that divergence within a regime affords niche actors to build alliances with regime actors. They argue that once initial overlap between niche and regime has been achieved, distinction between the two becomes less clear since it works to transform the whole niche-regime configuration. A similar remark comes from Smith (2007) who argues that in practice, the boundary between niche and regime is rarely so clear cut. Distinctions break down, the boundaries blur and a set of practices emerge and it might be difficult to classify them into two discrete set.

Apart from actor-network theory, there are other relationist approaches such as practice approach. Shove and Walker (2007) describe practice approach as a different way of thinking about transitions than the conventional systems approaches that "highlight the co-evolution of the social and the technical and which seek to understand and analyze the emergence, transformation and decay of socio-technical systems" (p. 763). Rather than approaching transitions as a set of activities to transform the incumbent technology, infrastructure, culture, networks, knowledge, policy and market to support a sustainable technology (Geels, 2002), practice approach emphasizes the constant interplays between technologies and meanings in actors' practices. Shove (2003) argues that in practice, the temporal and spatial characteristics of extending niches differ from case to case and that this extending process has no guarantee of success. Therefore, rather than only focusing on success stories where an innovation becomes embedded in society, Shove includes the double act of markets in enabling innovation as well as reshaping it via adding sociological and economic propositions on relation between consumer demand and specific context of innovation.

1.3.3 Proposing Transition in action

The selected literature above is built on productive frictions of different concepts (e.g., agency-power, agency-structure, niche-regime) and/or different perspectives (e.g., arena of development-multilevel perspective, actor network theory-multilevel perspective). I propose that these frictions, which emerge through interactions between heterogeneous actors, can inform a new assemblage of the conceptual and the empirical in transition studies. Following the same strategy as prior studies above, I use different, if not contrasting concepts or approaches to

capture frictions, controversies and tensions in practice. By clashing different approaches or concepts, I am able to bring attention to the following three elements in transition in action.

1.3.3.1 Non-linearity

The concept of non-linearity suggests output of a process as not directly proportional (or linear) to the input. Non-linearity proposes agency, as an emergent effect of actors' web of relations (Callon & Law, 1995), as steered not only by interactions between heterogeneous actors that leads to change in cognitive rules and expectations, but also through actors' individual interest towards the proposed innovation. This concept offers the possibility to capture the influence of negotiations between selfish actors that steer the innovation based on what matters for them. This non-linearity is produced through a chain of designing, adopting, re-designing and re-adopting. In other words, this process is made through constant work of enrolling heterogeneous actors since everyone shapes the innovation according to their different interests and webs of relations. Power of some over others is exercised by mobilizing all actors concerned to follow a particular script or message (Latour, 1986). It is an effect of actors' relations that perform and not a cause. The innovation changes as it moves from one actor to another. In this process, agency is distributed among actors within the designing-adopting chain.

1.3.3.2 Multiplicity

The concept of multiplicity suggests the presence of multiple realities, which are produced by the simultaneous enactment of heterogeneous actors to order and orchestrate a shared object in their own right (Mol, 2002; Law, 2004). It rests in assumption that enactment enables change as well as stability. In articulating the duality of enactment, I use the notion of values, defined as an existing set of calculations that guide a specific part of actors' routines to articulate stability and the notion of fantasies (e.g., dreams, hopes) defined as actors' calculations or rationales that guide actors' actions to modify routines to articulate change. Multiplicity is articulated via investigating how tensions between existing values and fantasies of a new innovation are being mediated in innovation enactment. Power is exercised through action to accumulate resources, both human and non-human actors to support a particular value and to go against other conflicting values. This conceptualization suggests agency as distributed across long chain of negotiations between normative values and fantasies. Each actor within these chains of negotiation produces its own version of an object and therefore, has equivocal evaluations e.g. failure of a government project is considered as success for the local authority since both of them have different criteria of success and failure. In this multiple ontology, actors' constellation follows a non-zero sum situation where one player's gain does not necessarily come at the

expense of other players. Actors' relations are interdependent rather than dependent and therefore, each of them contributes to success or failure of the project. The situation shows power as context specific than universal. Power of the central government to mobilize the local actors were strongly influenced by the fluidity of the project to be adjusted to local context, e.g. on how the project might increase farmers' welfare or benefit the local government.

1.3.3.4 Material Agency

The concept of material agency proposes that non-human actors, as human actors, have agency too. Non-human actors perform actions through their entanglement with other actors, which are constituted and shaped by their involvement with each other. This conceptualization suggests that power is not something one can possess, either it is human or non human actor, and that it must be treated as a consequence of interactions rather than as a cause of action. To investigate how non-human actors contribute in changing a course of actions, I incorporate a framework that works on the principles of distributed agency hybrid collectives of humans and nonhumans, translation (the process through which new entities are adjusted into hybrid collectives) and friction (material resistance or recalcitrance encountered in processes of translation). Material agency is captured through frictions encountered in the process of translation where one set of ties try to substitute another and through tensions between the two, transforming it. Through its entanglement with a set of ties, non-human actors are able to make others do things via resisting prior representations forced upon them and thus, reshape transition trajectory.

These three elements provide additional analytical devices to investigate transition in action. The first concept, *non-linearity* endows transition in action with certain characteristic that make an actor or a small group of actors less amenable to steer transition. The concept articulates transition in action by contrasting design and implementation of the program and also relation between actors that make transition happen. The second concept, *multiplicity* is introduced to articulate the relational and unstable configurations that emerge in transition in action due to interaction between heterogeneous actors and side effects of innovation. The third concept, *materiality* destabilizes the common perspective in Transition Studies that places agency as exclusive for human. To say non-human actors have agency means not to impose a precedence asymmetry between human's intention and non-human's materiality. As Chapter 2-5 show both human and non-human actors are able to steer transition into a certain direction.

Through performing the notions non-linearity, multiplicity and materiality in transition cases, I show different forms of agency and power. These differences are resulted by various frameworks that guide me to focus on different part of the cases. Connection between these multiple forms is linked through a 'coherent account' of performing a relational perspective,

while at the same time, allowing each chapter to presents its own versions of agency and power and to resist irrelevant definition proposed by others (Stengers, 2011:53). This coherent account links the different forms through a common principle of agency as an emergent effect of actors' action. The common principle allows plural embodiment of agency as a combination of actors' cognitive rules and expectations (Chapter 2), negotiations between normative values and fantasies (Chapter 3), entanglement between human and non-human actors (Chapter 4) and frictions epistemic culture (Chapter 5). Whereas for the issue of power, the coherent account links different forms of power through a common principle of being able to mobilize other actors to follow a particular order (or program). The plural forms of power are embodied in different sets of actions, in which each of them follows a specific script. Chapter 2 separates one set from the other through the notion script; Chapter 3 separates it through the notion fantasies; Chapter 4 separates it through the notion episode and Chapter 5 separates it through epistemic communities.

1.4 Research Questions

The above leads to the following two research questions:

Empirical RQ: *why did most small-scale biofuel projects in Indonesia stall despite much political and financial support?*

This contradictive situation, of being stalled and of having many supports to aid the projects suggests non-linearity. I shall show that this non-linearity was produced through multiplicity of the biofuel program and the projects within the program. The notion of multiplicity suggests that when actors enact the projects, they also enact its network, which includes material agency. Enactment of the latter affords non-linearity via redirecting objective of the projects and via changing the actors' network.

Conceptual RQ: *how can concepts of non-linearity, multiplicity and materiality improve understanding of transition in action, and in particular the role of agency and power in them?*

Here, I investigate to what extent non-linearity, multiplicity and materiality improve understanding of agency and power in transition in action. The key hypothesis is that agency and power are relational. Agency is exercised in practice, which through these practices afford the

establishment of power. The concepts of non-linearity accentuate relationality between agency and power by attaching agency of an innovation, as the object of transition in action, not only to the designer of the innovation but also to the set of the designer's alliances. The concept of multiplicity elaborates relationality between agency and power by focusing on enactment that emerge through intersection between fantasies of an innovation and the existing values that guide actors' routines. Agency and power are operated as mutually constitutive: that agency builds itself against power and vice versa. A set of alliances are mobilized to afford actors to do new things, but through these mobilization, it also forces actors to follow a certain program. The concept of materiality addresses relationality between agency and power by focusing on frictions that emerge through hbrid collective of human and non-human actors. .

1.5 Methodology

The dissertation argues that transition in action is not only about investigating ongoing cases but also about doing experimentation with new concepts in different fields of study. As a way to structure the experiment, I ground this dissertation in actor-network theory, a theory that instead of providing a coherent framework, offers a set of sensitivities to narrate cases and to draw contrasts (Law, 2009; Mol, 2010). Its principle to work on incoherent framework makes actor-network theory not a theory in conventional term. It understands the relationship between the conceptual and the empirical not as a matter of fact, where the former provides a coherent framework for the latter, but rather as a matter of concern, where both co-constitute the other (Stengers, 2011).

As a matter of concern, actor-network theory opens a possibility to engage with grounded theory-building approach (Eisenhardt, 1989; Corbin & Strauss, 1990; Suddaby, 2006). Eisenhardt (1989) describes theory-building approach as a research strategy that uses cases to construct new proposition or mid-range theory. Engagement between actor-network theory and theory-building approach allows me to have a meta-analysis where each case is articulated through different framework to frame the case in terms of absence of suitable theory and each of these articulations are being articulated again. This experimental approach is executed by conducting field works that cover participatory research and interviews, listening and re-listening record of the interviews, making notes, comparing and contrasting them and allowing the reoccurring theses to emerge inductively. Grounded theory seeks generalized patterns of the observed actors and how actors in different settings associate or differentiate themselves to and from these patterns (Corbin & Strauss, 1990).

I used a multiple-case design that allows me to build theory inductively via treating each case as a series of experiments, a medium to confirm or disconfirm the general patterns drawn from the others (Graebner, 2004; Yin, 2009). The dissertation includes four case studies of biofuel experiments in Indonesia. The four cases were built on contrasting concepts/approaches and on empirically contradictive situations. Two cases focus on an energy crop called Jatropha curcas (*jarak pagar*), a crop that had been believed to be able to grow in poor land, to improve the life of poor people and to solve the energy crisis (Scientist B, 2007). The two other cases focus on another energy crop called Calophyllum inophyllum (*nyamplung*), a crop that was believed to be able to produce more oil than Jatropha and would provide additional income for poor farmers since it was an existing crop and no initial capital is needed to cultivate them.

Prior studies have suggested that the narratives of framing Jatropha as a super crop (i.e., suitable for marginal lands, require low maintenance) contributes to failures in Jatropha projects (Afiff, 2014) since it has little resonance with realities (Ariza-Montobbio et al., 2010). These studies suggest failures of the projects as being path-dependent to its past frames. Through this dissertation, I want to challenge this path-dependency idea by proposing that success and failure of a project rests on its continuous actions of enrolling heterogeneous actors (Latour, 1996; Mosse, 2004). These activities afford emergence of convergent network in which human beings and technical objects interact predictably (Callon, 1990) or a negotiated space where actors held together through a thick combination of being partially related (Mol & Law, 1994). Therefore, the ambition of this dissertation is to take emergent spaces, present in the form of controversies, frictions and negotiations among actors as the unit or focus of attention.

Informants included individuals from the emergent spaces who were most involved in steering and/or modulating the spaces. I identified informants through "roll a snowball" and "follow the actors" (Bijker, 1995). The snowball method allowed me to start with a limited number of actors (identified during initial desk study) where at the end of each interview, I asked my informants about who else should I interview to get a complete picture of the controversies/emergent spaces. After having a list of relevant social groups via snowballing, I followed these actors to get more details via participatory research (i.e., meeting these actors several time in three-year period, following them to government meeting, inviting them to triangulation workshop).

1.5.1 Case Selection

In choosing the case studies, I considered variety in settings, initiators and strategies of the projects. These criteria brought me to the following cases:

Table 1.1 Cases of the dissertation

Crop and place	Initiator	Strategies
Calophyllum-based fuel project in Purworejo district	The national government	Formal institutional devices (e.g. regulations, subsidies, grant)
Calophyllum-based fuel project in Purworejo district	Entrepreneurs from Yogyakarta	Actors build up institutional support from a religion leader in Purworejo and Kebumen areas and the district government of Purworejo
Jatropha-based fuel project in Grobogan district	The national government	The national government encouraged two of its State Own Enterprise to develop pilot projects
Jatropha-based fuel project in Sumbawa district	Scientists and local entrepreneurs	The collaborations allowed the local entrepreneurs to extend the scientists' capital including technology and sponsors.

These four case studies performed the same experimental biofuel project, started from a similar fantasy of growing a multi-purpose crop and generated frictions due to its complexity. Yet they had different initiators and were built on two different crops. Calophyllum was assumed as an existing crop that grows in the wild and thus, does not need planting, while Jatropha needed to be planted first. These different assumptions were performative in shaping the proposed business model, which affect actors' strategies. Through these similarities and differences, I will show that one possible source of actions is driven by not only by actors' calculations/rationales to achieve the best possible option between human preferences and natural conditions but also through uncertainty in predicting the behavior of non-human actors. This dissertation offers multiple ways to understand agency and power in transition by focusing on different sources of actions.

1.5.2 Data Collection

I use multiple sources of evidence: a) 60 in-depth interviews with highly knowledgeable informants from universities, entrepreneurs, farmers, the local governments in Bandung, Bogor, Grobogan, Yogyakarta, Kebumen, Purworejo and Sumbawa and national policy makers in Jakarta; b) participatory observer in Yogyakarta, Grobogan, Kebumen, Purworejo and Sumbawa for a total of six months spread across June 2007 and May 2012; c) one national workshop (attended by representatives from 15 institutions), a local focus group discussion in Purworejo (attended by representatives from 30 government/local institutions) and a local workshop in Yogyakarta (attended by representatives from 10 local institutions); and d) written materials. These materials were gathered through my involvement as a participant observer in two research

projects concerning developmental universities and inclusive biofuel innovation, both related to Indonesia. The interviews were typically 60-120 minutes in length. The primary source was following 10 key actors across five years of research. During this period, I interviewed the main informants several times, so I was able to capture their actions from one situation to another. Prior to the main data collection effort, I created a timeline based on the secondary data. When I met my informants, I triangulated the validity of this timeline and their position in the timeline, and I also asked them to refer me to new informants.

1.5.3 Data Analysis

I analyzed the data by firstly looking for evidence on controversies and/or negotiations among actors and then, by analyzing how the process afford emergence of a new space. Actors' ability to meet their interests, articulated in this dissertation through the notions protective space, fantasies, materiality and knowledge, represent power. However, it is the distributed agency that steers actions and allows emergence of new space. In capturing tension between agency and power, I used contrasting concepts/approaches to accentuate tensions in practice (Table 1.2).

Table 1.2 Concepts, indicators for the empirical and its relation to agency and power

Conceptual	Looking for evidence of	Relation to agency and power
• Protective space: a configuration that allows the experimentation of a new environmentally sustainable technology in certain application domains. • Script: elaborate the reciprocal relationship between in-scription, i.e. activities of embedding a script into a program,, and de-scription i.e. activities to interpret the program and to materialize this interpretation in practice	• How the issues of agency and power are being addressed in the case study? • How the empirical materials allow linkage between the concept of agency and power and protective space and scripts? • How do the linkage from the empirical materials provide a line of argumentation for analyzing transition in action?	Agency is exercised in practice, which through these practices afford the establishment of power. The concepts of non-linearity accentuate relationality between agency and power by attaching agency of an innovation, as the object of transition in action, not only to the designer of the innovation but also to the set of the designer's alliances
• Fantasy: actors'	• Informants' statements	Power is articulated through

Conceptual	Looking for evidence of	Relation to agency and power
calculations or rationales that guide actors' actions to modify routines • Value: an existing set of calculations that guide a specific part of actors' routines	(and supporting materials) about functions of Jatropha innovation for the informants • Contrast between situations where dimensions of fantasy were present and were absent and how these opposite situations relate to their values and the trajectory of biofuel innovation in Indonesia	activities of enrolling heterogeneous actors to follow a shared fantasy. This exercise of power is performed in a composition of networks where actors have multiple values. Interaction between activities to support fantasy and activities to conserve the existing values via adjusting the materialization of fantasy afford emergence of **multiple** spaces. These spaces are constituted by interactions between heterogeneous actors that make it up.
• Translation: the process through which new entities are adjusted into a hybrid collective • Hybrid collective: agency is distributed in a network of human and non-human actors	• How the project is continuously being transformed? • Who are the key actors for these transformations? • How material resistances or recalcitrance encountered in processes of translation?	**Material agency** is articulated through its ability to modulate trajectory of the experimental project via limiting agency of human actors. It shows that agency is distributed among human and non human actors and that power performs through a constant struggle between different interests, identities and interpretations.

1.6 Outline

In Chapter 2, I focus on *how the design of Indonesia's biofuel policies has shaped the socio-technical configuration of experimental projects?* This chapter investigates 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.

Chapter 3 focuses on *how fantasies of Jatropha impact research and innovation, and how actors' values shape Indonesia's biofuel trajectory?* This chapter develops an analytical framework that combines the concepts of technological fantasies and normative values. In other words, it utilizes dimensions of fantasies to elaborate how heterogeneous actors became embroiled in Jatropha innovation. At the same time, it investigates the presence of various normative values such as faith in technocracy and beliefs about developmentalism that emerged in and through actors' multifarious involvement with biofuel. The analysis shows that Jatropha innovation in Indonesia was intricately shaped by beliefs cutting across preserving routine and the will to change.

Chapter 4 focuses on *how do things constitute actual implementation and discursive practices in development projects and programs?* This chapter addresses this question via a conceptual framework that works on the three concepts of *distributed agency* (in hybrid collectives of interrelated humans and nonhumans), *translation* (the process through which new entities are adjusted into hybrid collectives) and *frictions* (material resistances or recalcitrance encountered in processes of translation). The analysis shows that things shape development practices: a) by limiting the agency of human actors, b) by resisting representations of actual events produced by human actors, c) through biophysical change to their weight or textures as they move in space and time, and d) by making and unmaking asymmetric relations of power.

Chapter 5 focuses on *how Jatropha travels from the scientists' laboratory in Bandung to the entrepreneur's factory and farmers' land in Sumbawa?* This chapter addresses this question via a incorporating the notion entanglement. The notion suggests that interactions between heterogeneous elements affords emergence of new agencies. This framework was useful to capture the multiple orders in the relationship between science and society apart from the instrumentalist approach suggested in Triple helix model (e.g. Leydesdorff and Etzkowitz, 1996) as one of the models to explain innovation. Entanglement between practices of nationalism and science affords the emergence of Jatropha knowledge in the university. This entanglement was followed by different types of entanglement, which afford Jatropha knowledge to travel to the policy makers' offices, to industry and to farmers' fields.

The concluding Chapter 6 summarizes the major findings by providing conscience arguments to the research questions. It argues that innovation practices affords non-linearity between design and implementation of a program and also between actors that entered and drop off from the program, multiplicity between different actor-networks and for materials to shape

innovation practices. The relation between agency and power is mutual inclusive; interactions between actors that perform allows agency and steer their behavior (by forcing them to coordinate change).It also reflects on the benefits and limitations of doing transition in action and makes suggestion for further research. In this chapter, I place particular emphasize on the novelty of adopting multiple frameworks. Through introducing different frameworks, I embrace the agency of my actors via allowing them to be narrated by different perspectives.

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2. Scripts in Transition: Protective Spaces of Indonesian Biofuel Villages[1]

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.

Keywords: policy design, policy implementation, experiments, projects, protective space, script, actor-network theory

2.1 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 & 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

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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 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 & 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 in-scribed) 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 thirteen 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.

2.2 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.

2.2.1 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.

2.2.2 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 Figure 2.1-2).

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 Figure 2.1-2). 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).

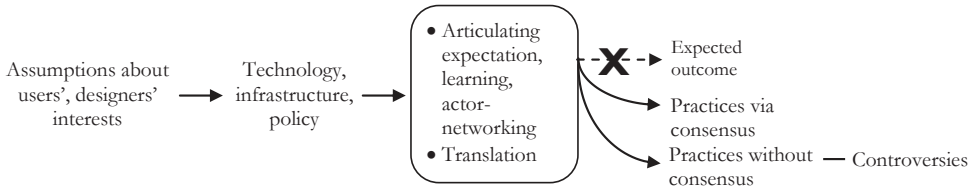

Figure 2.1 Translation

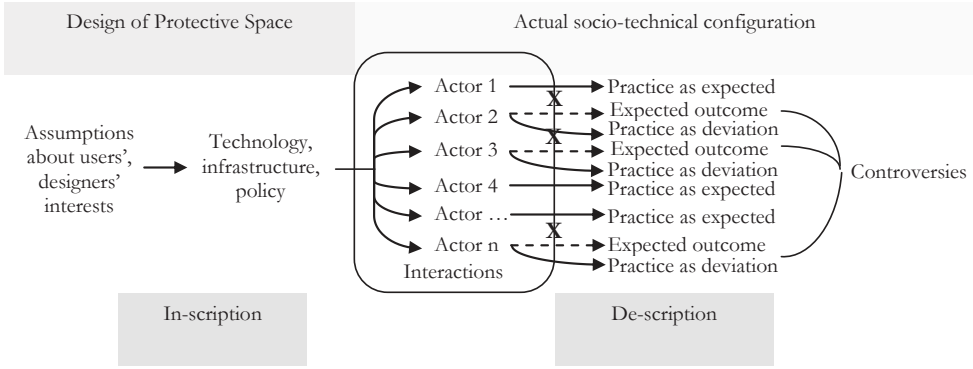

Figure 2.2 Script

2.2.3 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 three 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.

Figure 2.3 Fieldwork areas

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.

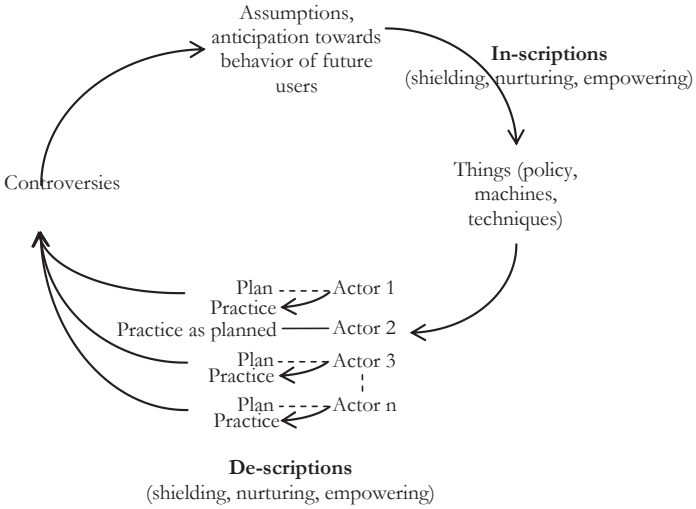

Figure 2.4 The cycle of in-scription and de-scription

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. 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 2.1 below.

Table 2.1 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)?

2.3 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.

2.3.1 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 three-month financial support from the central government to run the production of biofuels.

2.3.1.1 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 below the poverty line.[2] 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 & 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 three 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

[2] He mentioned it in the biofuel conference in Brussels, July 5th, 2007

per month and the biofuel feedstock (Calophyllum fruits) collectors could receive an additional income of 11 cent per kilogram. To ensure availability of buyers, the central government instructed state-owned enterprises to buy the biofuel produced in villages.

2.3.1.2 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 meter high, low branching tree. According to the scientists, Calophyllum seeds yielded 40% of their weight in oil (Sudrajat, 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.

2.3.1.3 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 per cent of total energy consumption) and 43 per cent 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.

2.3.2 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 one litre 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.

2.3.2.1 Shielding: Emergence of New Biofuel Activities

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 hectares. This plantation was followed by similar activities on larger areas in 1977 and in 1980, resulting in 136 hectares 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 (<100mm) (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 hectares), house and garden (72,049 hectares) and forest (61,500 hectares) (Bustomi et al., 2010). In 2008, most people worked as farmers (5,336 out of 5,914 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 20000 new Calophyllum trunks in an area of 50 hectares.

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.[3]

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 tons of Calophyllum fruit per month. According to a household survey among farmers of Kebumen and Purworejo conducted by the Kyai, their maximum

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

income was around 3.3 dollars per day, which they were able to supplement by more than 1.3 dollar 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.[4] 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 kilogram 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 cent 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.[5]

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.[6] 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 2,470 kilometers.

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 ten 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 ten million were paid by three state-owned enterprises: Pertamina, Rajawali Nusantara

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

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

[6] 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.

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.[7] 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, they could not have managed the 10 million dollars (or any other funds from the central government) "without an additional regulation that justifies it."[8] 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.

2.3.2.2 Nurturing: Controversies over Protective Space Practices

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

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

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

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.[9] 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 kilogram of Calophyllum fruit into 60 liters of biodiesel.[10] 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.[11] 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."[12]

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 one week of work would be

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

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

[11] Ibid.

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

followed by a stoppage of two 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 kilograms Calophyllum fruits that he received from the collectors, he was only able to produce 171 kilograms kernel, which after the processing resulted in 49.5 liter of Calophyllum oil. This number suggests that in order to produce a liter of oil, they required about 15 kilograms 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, the government provided the processing unit with 200 liters 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.

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.[13] Unfortunately, cooperation between the entrepreneur, the ESSV cooperative and an energy provider company for BTSs based in Jakarta only lasted for six months. The representative of the Grobogan cooperative blamed the entrepreneur for running

[13] 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 et al., 2009). 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 litres of diesel per month.

away from the site without any explanation and for exaggerating the possible benefits,[14] while the entrepreneur claimed that an internal conflict between cooperative members was the reason why he left Grobogan.[15]

2.3.3 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.

2.3.3.1 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

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

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

> 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.

2.3.4 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.

2.3.4.1 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,

> "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."[16]

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.

2.3.4.2 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 litres per month (in contrast to the production capacity of 400 litres 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

[16] Workshop in Purworejo, April 10th, 2012.

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. 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.

2.3.4.3 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.

2.4 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 2.2.

Table 2.2 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 fifteen 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 three 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

	In-scriptions	Objects	De-scriptions
			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	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**.**

	In-scriptions	Objects	De-scriptions
	created a shield consisting of local actors.		
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.
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).

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 & 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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3. Fantasy, Values, and Identity in Biofuel Innovation: Examining the Promise of Jatropha for Indonesia[17]

Abstract

This paper addresses how fantasies of Jatropha impact research and innovation and how actors' values shape Indonesia's biofuel trajectory. The paper develops an analytical framework that combines the concepts of technological fantasies and normative values. In other words, this study utilizes dimensions of fantasies to elaborate how heterogeneous actors became embroiled in Jatropha innovation. At the same time, the study investigates the presence of various normative values, such as faith in technocracy and beliefs regarding developmentalism, that emerged in and through actors' multifarious involvement with biofuel. The analysis indicates that Jatropha innovation in Indonesia was intricately shaped by beliefs cutting across governance and governmentality, alienation and marginalization. The paper places these observations within the wider context of science and technology studies and, more particularly, within the issue of fantasy and innovation practices in energy technology adoption, use, and policy.

Keywords: biofuel, enactment, innovation, Jatropha, fantasies, values

3.1 Introduction

In February 2007, the Indonesian President visited Grobogan district to launch the Jatropha Energy Self-Sufficient Village project. This project was intended by the government to create job opportunities, reduce poverty and provide energy in remote villages (GFA, 2008). In front of Grobogan farmers, the President described the project as being able to improve their welfare by providing additional income. He announced that Energi Hijau Lestari, a subsidiary company of Indonesia's leading sugar state-owned enterprise, would buy and process the harvested seeds into crude Jatropha oil.[18] Apart from this institutional support, he allocated 10 billion IDR (USD 1.1 million) to boost the project. One of the farmers who attended the occasion related that his faith

[17] This chapter is based on: Fatimah, Y. A. (2015). Fantasy, values, and identity in biofuel innovation: Examining the promise of Jatropha for Indonesia. *Energy Research & Social Science*, *7*, 108-116.

[18]Transcript of dialog between the Indonesian President and Jatropha farmers, February 21, 2007.

in the future of Jatropha was based on the President's presence in Grobogan.[19] Despite the political and financial support from the central government, market support from the private sector, and labor support from the farmers, Jatropha failed to sustain in Grobogan and in other areas in Indonesia (e.g., Amir et al., 2008; Vel, 2014).

The Director of the Surfactant and Bioenergy Research Center of Bogor Institute of Agriculture saw the government's policy to support Jatropha innovation as appropriate and pointed to low productivity as the reason behind Jatropha's development failure in many areas;[20] By contrast, the representative of the Coordinating Ministry of Economic Affairs saw a lack of coordination between different institutions as the reason behind the Jatropha failure.[21] The variation in actors' interest in getting involved in the Jatropha development and in the actors' explanations on its failure implies a lack, if not absence, of shared interpretation. In 2007 in Grobogan, Jatropha acted as a solution for solving rural problems for the President, as an obligation to follow the President's instruction for the company and as a promising crop for the farmers. In 2011, Jatropha enacted researchers and the biofuel company as having low productivity. These differences were not different perspectives on a single crop. Rather, each of these assessments or calculations generates different realities based on how the actors saw and were being enacted by the crop (cf. Mol, 2002 on arteriosclerosis).

These fantasies and disappointments in Jatropha's development in Indonesia share many similarities with the global trend. From 1994 until 1997, there was a relatively large Jatropha research project in Nicaragua, which resulted in several scientific publications on Jatropha potential (e.g., Foidl et al. (1996), Gübitz et al. (1999)). Attention on Jatropha was renewed when the Indian Planning Commission in 2003 focused on Jatropha as the most important opportunity to reach national blending targets, aiming at fuel independency and climate mitigation.[22] Jatropha attracted global biofuel interest through fantasies of being able to produce biofuel and enhance socio-economic development while reclaiming marginal and degraded lands in semi-arid regions (Francis et al., 2005). These promises were materialized in directives and blending targets (e.g., European Union, 2009; India, 2003) and triggered large-scale investments and plantations (in Achten et al., 2010). Francis et al. (2005) and Achten et al. (2010) address the problem of Jatropha fantasies and their poor materialization in practice by requesting more

[19]Kompas, March 7, 2011. "MinyakJaraktelantar"

[20]Ibid.

[21]Statement from the representative of the Coordinating Ministry of Economic Affairs on a national workshop entitled 'Where Indonesian biofuel are going to be brought?' May 15, 2012 in Bandung.

[22]Personal communication with WouterAchten, February 18, 2011.

communication among actors on correct information regarding land suitability, risk of yield loss and possible water competition. This suggestion pays little attention to the politics of fantasies and to the possibility that actors maintain ambivalence in promises to support their interests.

Prior studies on expectation and fantasies in innovation research have focused in particular on the poor conceptualization of interdependencies between technological development and the society (Geels & Smit, 2000), actors' roles embedded in expectations (Brown & Michael, 2003), performances of fantasies in allowing particular actors such as entrepreneurs to obtain financial and legal support (Sovacool & Brossman, 2013) and different visions within fantasies that are active in shaping social expectations (Sovacool & Ramana, 2015). These studies explain the success and failure of expectations and fantasies in generating support from various actors (scientists, regulators, publics, etc.) from a single perspective of the development of innovation. Sovacool and Brossman (2013) show how interactions between fantasy and development of energy technology were mobilized at the expense of some social and environmental costs.

This latter remark calls for an alternative framework that is able to explain how and why social and environmental actors were excluded from innovation performances. I propose that the process of exclusion and inclusion in innovation performances, which re-shape innovation trajectories, can be investigated by multiplying the perspective and, empirically, by seeking multiple sources of action. In a single perspective, non-linearity in innovation performances is identified by how it does not follow the initial conceptualization. It is a binary relation, *A* and non *A*, where non *A* is explained through its difference to *A*. While in a multiple perspective, non-linearity is identified by how actions follow different calculations. It is a plural relation, *A* and *B*, where *B* has its own justification. To support this proposition, I develop a framework that combines two opposing calculations: fantasies and values. Fantasies refer to actors' calculations or rationales that guide actors' actions to modify routines, while values refer to an existing set of calculations that guide a specific part of actors' routines.

I chose a research question on how fantasies of Jatropha impact research and innovation and how actors' values shape Indonesia's biofuel trajectory. I will justify my approach in terms of extending studies on fantasies and innovation performances and theory building. The justification starts by firstly presenting foundational assumptions, prior concepts that I use to build propositions for this paper and empirical questions that allow me to link the proposition and the empirical evidence in Section 2 (Eisendhardt & Graebner, 2007). Section 3 provides empirical evidence, results and discussion of the framework in which I show that the case supports the proposition and that it allowed me to show the presence of five types of values. I

end this paper with a conclusion section, where I discuss implications of this study within the wider context of energy research and science and technology studies literature.

3.2 Theory and Methods

The research approach I used in this paper is theory building methodology (Eisenhardt, 1989; Graebner, 2004; Eisenhardt & Graebner, 2007). This methodology refers to a strategy to construct a theory or proposition from one or more case studies. In theory building, the case is selected because it is suitable for highlighting relationships among constructs within the proposition (Eisenhardt & Graebner, 2007). I chose this methodology because prior theory and research regarding relations between fantasies and values in shaping actors' enactments in innovation practices are lacking. I start building the theory by providing underlying conceptual assumptions that provide the logical link between the constructs within a proposition. To make the foundational assumptions visible and to see relationships between assumptions, the analytical framework and the empirical materials, I divide this section into three parts: assumptions and definitions, the analytical framework based on prior studies on research and studies, and the empirical materials and questions that bridge the theoretical construct and the empirical evidence. This approach places questions as a source for structuring the paper as well as a set of propositions that are strengthened through empirical evidence.

3.2.1 Foundational Assumptions

Enactment refers to performance by heterogeneous actors to order and orchestrate entities in their own right (cf. Shove & Walker, 2010 on practice). It claims that relations are continually brought into being through endless performances and have no reality outside these performances. It suggests that institutions, market or economics take different forms in different places and, more importantly, that these orders (or structures) are not real until they are enacted (or performed) (Callon, 1998; Law, 2009). The notion of attending orders behind actors' actions is not in itself novel. Scholars such as Simon (1972) and March (1978) have, for instance, included the concept of bounded rationality to articulate actors' decisions as being limited by their *given* conditions and constraints. By taking into account actors' limitations, they argue that rationality should be seen as situated and localized instead of general and universal. However, the actors' situatedness or localization, according to Boli and Lechner (2009), is better understood as social enactment rather than as (boundedly) rational action. In enactment, actors' limitations, as a consequence of structure, cannot be seen as something passive lying 'out there' waiting to be discovered, but rather these limitations are constantly brought into being in and through everyday performances.

I elaborate actors' enactment in terms of *homo economicus 2.0*, defining calculative actors as those whose calculative sources are distributed within a network of human and non-human actors (Callon, 2008). In science and technology studies literature, there are different ways of articulating heterogeneous calculations, rationales, values, modes, concerns or registers. Scholars such as Heuts and Mol (2013) and Law and Lien (2013) propose to group actors' concerns based on what they found in the empirical materials. Other scholars such as Boltanski and Chiapello (2005) and Latour (2013), on the other hand, propose grouping actors' concerns based on conceptual historical analysis of emerging core values in the Western world. Despite their opposite starting points, these scholars agree that these registers or rationales are continuously contested.

Eisenhardt and Graebner (2007) suggest that in theory building methodology, narrative from the empirical materials intertwines with the theory and is maintained at the forefront of the paper. This remark brought me to take a combination trajectory between empirical and conceptual, in which I extract the empirical evidence within the context of the conceptual and then show how inductive theory building is necessary.

3.2.2 Fantasies and Values

This paper centers on building a theory about innovation performances as constituted by fantasies and values. Bormann (1985) uses the notion fantasy in symbolic convergence theory, referring "to the creative and imaginative shared interpretation of events that fulfills a group psychological or rhetorical need" (p. 130). Fantasy performs as rhetorical visions, which maintain communities of actors in a social reality that accommodates their psychological or social needs (Sovacool & Brossmann, 2013). In this article, I expand this conceptualization of fantasy by focusing not only on its ability to accommodate heterogeneous interests (e.g., Berkhout, 2006; Borup et al., 2006) and its materialization in practice (Sovacool and Brossmann, 2013) but also how it is being adjusted by the presence of value.

Sovacool and Ramana (2015) argue that technological fantasies have four dimensions. The first dimension is *functional* and presents new technologies as being able to function more effectively than an existing technology that they are trying to replace. This presentation is performed by excluding other possible effects such as social and psychological and, thus, the future images become too optimistic (Geels and Smit, 2000). The second dimension is *utopian*. It presents new technologies as enacted in a perfect society where actors are only interested in societal improvement and have no personal interest. This utopian dimension of fantasies leads to an unrealistic plan for new technologies. The third dimension is *contradictory*. It presents new technologies as being able to address multiple problems that do not necessarily go along

together. Van Lente (1993), for instance, shows that visions of a hydrogen economy contradicted each other (in Sovacool and Ramana, 2015). The fourth dimension is *selective*. It highlights the potential benefit of new technologies by leaving out their potential challenges. This representation incorporates new technologies uncritically because it only acknowledges the positive side of new technologies. In the present study, I propose that the presence of these dimensions can be used to explain actors' attachment when these dimensions are present, and detachment to new technologies when at least one of the dimensions is absent.

One of the main challenges of mobilizing fantasies is to generate strategies in a context of plural or conflicting calculations. The role played by adding values to innovation performances is to articulate the presence of alternative objectives and/or multiple sources of power, which may enroll innovation performances into different trajectories. I incorporate the notion value by referring to it with respect to different types of common goods. This means that value is not related to different groups as suggested in classical sociology, but rather to different situations (Boltanski & Thévenot, 1999). Thus, an actor may have multiple values depending on his/her situation. These values are grouped based on superior calculations that define actors' attributes in any social situations.

3.2.3 Empirical Materials

I use multiple sources of evidence: a) 29 interviews; b) field work in Bandung, Jakarta and Grobogan for a total of six months spread across June 2007 and May 2012; c) interviews with highly knowledgeable informants from universities, the local government of Grobogan and national policy makers; d) the organization of one national workshop; and e) written materials. These materials were gathered through my involvement as a participant observer in two research projects concerning developmental universities and inclusive biofuel innovation, both related to Indonesia. The primary source was more than 10 semi-structured interviews with individual informants across five years of research. During this period, I interviewed the main informants several times, so I was able to capture their shifts from one value to another. The interviews were typically 60-120 minutes in length. Prior to the main data collection effort, I created a timeline based on the secondary data. When I met my informants, I triangulated the validity of this timeline and their position in the timeline, and I also asked them to refer me to a new informant.

I analyzed the data by firstly looking for evidence on how the data may fit or not fit with the four dimensions of fantasies and by identifying different situations based on informants' values and, secondly, by analyzing the combinations of these contrasting calculations and how they influence innovation performances (see Table 3.1).

Table 3.1 Concepts, function and indicators for analysis

Conceptual lens	Description	Looking for evidence of
First Iteration		
Functional	It presents new technologies as being able to function more effectively than an existing technology that they are trying to replace	Informants' statements (and supporting materials) about functions of Jatropha innovation for the informants
Utopian	It presents new technologies as enacted in a perfect society where actors are only interested in societal improvement and have no personal interest	Informants' statement (and supporting materials) regarding how one actor talked about how other actors may support Jatropha innovation
Contradictory	It presents new technologies as being able to address multiple problems that do not necessarily go along together	Informants' statements and supporting materials about Jatropha promises
Selective	It highlights the potential benefit of new technologies by leaving out their potential challenges	Informants' statements and supporting materials about Jatropha potential challenges
Values	Superior calculations that define actors' attributes in any social situations	Competing calculations that steer Jatropha innovation trajectories (e.g., by becoming different than planned)
Second iteration		
Fantasies and values	It investigates the relation between fantasies and values within the empirical evidence	Contrast between situations where four dimensions of fantasy were present and were absent and how these opposite situations relate to their values and the trajectory of biofuel innovation in Indonesia

3.3 Jatropha Innovation in Indonesia

This section groups informants' fantasies (or the lack of them) and their values about Jatropha into five clusters. These clusters have to do with technocracy, developmentalism, governmentality, alienation and subalternism. The first three values meet the four dimensions of fantasies of being functional, utopian, contradictory and selective, whereas the other two values do not meet at least one of these dimensions.

3.3.1 Technocratic

In May 2007, I met scientist A in his laboratory at the Bandung Institute of Technology. For him, the momentum for Jatropha initiatives started in 2003 when he and his colleagues from Indonesian Biodiesel Partnership (IBP) went to the parliament. In the meeting, he highlighted the urgency to develop biofuel and the superiority of Jatropha among thirty other potential energy crops. His colleague from the Department of Agriculture strengthened scientist A's preference for Jatropha by conveying that his department had a program to cultivate Jatropha in West Nusa Tenggara. He expected the parliament to be able to develop a Jatropha mechanism

that would benefit the local community and not large companies as had happened in the palm oil business. In response, the parliament said that they were interested in biofuel and Jatropha in particular and invited IBP to their next meeting, which would compose the new energy law.[23]

While waiting for political and financial support from the central government, IBF continued their activities in developing Jatropha by composing an action plan. This action plan set the ideal roles for the Department of Forestry, Department of Agricultural, Lemigas, BATAN and the Agency for Assessment and Application of Technology (BPPT) in Jatropha development from 2003 to 2010. Scientist B told me that Jatropha activity at BPPT had started in 2004 through their collaboration with the New Energy and Industrial Technology Development Organization (NEDO) Japan and the local government of West Nusa Tenggara. This collaboration produced an international workshop on biomass and clean fuel power plant technology and was continued by a two-year research project on Jatropha for generating power in remote areas. In the same year, this collaboration was extended by involving the Institute of Technology Bandung (ITB)—via scientist C and his research group—and Mitsubishi Research Institute to further investigate the characteristics of Jatropha oil. The research showed that crude Jatropha oil could be used to power electricity generators.

Scientist C told me that what made him different from other researchers was his method that allowed pure Jatropha oil to be used directly in machines without adding alcohol and acid to the oil, which made the production expensive. To strengthen his network, scientist C, with the Indonesian Farmers Group, Bogor Agricultural University (BAU) and one of the biggest Islamic organizations, *Nahdatul Ulama*, made a declaration to support Jatropha development as part of the national energy program in 2005. To mobilize political and financial support, scientist C, with financial support from National Geographic Indonesia, BioChem Prima International and Biotechnology Research Center ITB, held a 3,000 kilometer road test called Jatropha Expedition 2006. This expedition succeeded in mobilizing political support from the national government and the provincial governments of West Nusa Tenggara, East Nusa Tenggara and Bali and in attracting investors to develop Jatropha.

In this cluster, Jatropha enacted other actors via technocracy, which emerged through entanglement between Jatropha and scientists. These calculations meet the overarching dimensions of functionality, utopianism, contradiction and selectivity. The technocratic calculations yielded Jatropha as superior to other energy crops and suitable for power generation and as fuel for cars. The calculations were utopian because the action plan constructed by the human actors assumes Jatropha and the other actors/institutions to be apolitical and perfect.

[23]Archives of the Indonesian Biodiesel Forum.

Contradictions in approaching Jatropha among different scientists were maintained through mobilizing resources from actors who supported their approach while avoiding discussing details with actors who had different approaches (e.g., relationship between scientist A and C). This strategy follows the selective dimension of fantasy, in which the scientists frame their rhetoric strategically based on what they see as important.

3.3.2 Developmentalism

In July 2006, the Indonesian President convened a special cabinet meeting to mobilize commitments from various stakeholders to develop biofuels. The plan aimed to improve energy security, to boost economic growth and to reduce poverty in rural areas (Wirawan and Tambunan, 2006). In the meeting, the President highlighted that the 2006 crisis was caused by following wrong approaches, prescriptions and policies, and therefore he suggested the urgency to have a "New Deal" to create jobs and to prevent the suffering from the crisis (Yudhoyono, 2006). Initially, the plan envisaged producing biodiesel predominantly from Jatropha oil (Dillon et al., 2008). This developmental calculation refers to a call to shift the Indonesian macro-economic policies from only focusing on market mechanisms to including a poverty reduction program.

With regards to this new approach, the vice governor of East Nusa Tenggara, when welcoming the Jatropha Expedition 2006 team in the mayor's office in Belu, highlighted, "We want to participate in the national renewable energy program. However, we must see how this program can contribute to rural development, poverty reduction and job creation in this area. We are hoping that health and education services can also be improved."[24] As part of supporting the national program, his apparatus had planted 653 hectares of Jatropha. Despite this contribution, he reminded the farmers to cultivate Jatropha only in poor land where paddy, corn and beans could not grow.

A year later, the provincial government of East Nusa Tenggara together with the Ministry of Agriculture held an evaluation workshop. The workshop was attended by the apparatus of the provincial government, local universities, NGOs and industries. One of the companies explained that despite legal support, his company still struggled with continuity of Jatropha supply. Another company expressed his concern regarding land distribution in East Nusa Tenggara, which was organized under *hak ulayat*, the collective right of residents in a village to a piece of communal land. Therefore, he suggested, Jatropha development could only work through collaboration between cooperation and the village community. A representative from

[24]Kompas, July 14, 2006. "Masyarakat NTT BerharapBanyak."

the local government suggested that the Jatropha venture should be started with a pilot project and be handled by the government and not by the private companies. Therefore, the government can maintain continuity of Jatropha supply. The State Electricity Company said that they are ready to buy Jatropha from the farmers to replace diesel (GFA, 2008).

In this cluster, Jatropha enacted other actors via developmentalism, which emerged through entanglement between Jatropha and the central and local government. These calculations met the overarching dimensions of functionality, utopianism, contradiction and selectivity. The developmental calculations assumed that Jatropha was able to address poverty problems, create jobs and contribute to rural development. These assumptions were utopist because they were performed on the assumption of a perfect society where personal gain is argued to stem from and be synonymous with the national gain. Contradictions within these expectations appeared in the workshop between the local government that wants to develop Jatropha by stages and private companies that want to have Jatropha on a large scale. Each of these actors conveyed their fantasies about Jatropha in the workshop selectively based on what matters for them.

3.3.3 Governmentality

To boost biofuel and Jatropha development, the government issued a set of new regulations, consisting of Presidential Instruction No. 1/2006 on the supply and use of bio-fuel as an alternative fuel and Governor Decree No. 296/KEP/HK/2006 on formulating a supervisory team and coordinating team for Jatropha development. These regulations were followed by the establishment of 57 pilot projects by the national government, machines and technical support from the Department of Industrial Affairs in 52 villages and 3 pilot projects by Rajawali Nusantara Indonesia (RNI), a state-owned enterprise (Timnas BBN, 2007). In addition to this support, the President visited one of the RNI pilot projects in Grobogan in February 2007. The President used the occasion to have a dialog with Grobogan farmers in which he guaranteed the performance of the Jatropha market.

> "If no one buys your Jatropha, then report it to me. We had designed the business model carefully. As long as the fruits and oil are good, we are going to buy them. We have the market and therefore, there is no risk for Jatropha. So please plant Jatropha and produce a good one and with God's will, all of them will be bought. Thus, no one will be disadvantaged."

As an addition, he promised the farmers' groups the provision of a ten billion IDR fund for Jatropha development.

A representative of Pertamina commented, "Every time the President visits a place, he has to make a donation. This time it was Pertamina, state gas company and RNI that were being asked to donate for the President's promise to the local community. Pertamina donated 9.9

billion IDR and the other each donates 50 million IDR."[25] On the same occasion, the President announced that Energi Hijau Lestari, a subsidiary company established by RNI in Grobogan in 2005, would be involved in the Jatropha project (Simandjuntak, 2014). The intended function of this company was to buy Jatropha fruit from the farmers, to process the fruit to pure plant oil and to sell it to RNI. The representative of RNI explained that they offer two types of collaboration. The first one is where the farmers sell dry Jatropha seeds to RNI for 700 IDR per kilogram and the second is through a profit sharing mechanism where farmers may receive 1050 IDR per kilogram.[26]

I traced how these promises enacted Grobogan farmers through farmer A, who said his involvement with Jatropha was motivated by the President's presence in Grobogan. "The President came by himself to Grobogan. That is the reason why I believed in Jatropha at that time."[27] Another farmer, B, said that he felt lucky for being able to shake the President's hand. This experience, however, came with a price. After the President promised to give the farmers' groups ten billion IDR, many people came to his house to ask for part of the ten billion IDR. "Since my husband shook hands with the President, many farmers thought the money was handed to him. They were thinking that my husband kept the money for himself,"[28] said farmer B's wife.

In this cluster, Jatropha enacted other actors via governmentality, which emerged through entanglement between Jatropha and the central government. These calculations combined dimensions of functionality, utopianism, contradiction and selectivity in orchestrating farmers' modes of thought of having the honor to be visited by the President and the act of governing by issuing a set of new regulations and by mobilizing resources to support Jatropha development. Jatropha enacted the farmers through promises of Jatropha being bought and of receiving part of the 10 billion IDR. These promises were utopist in the sense that they assumed that the President's statement was a warranty for Jatropha success. In promoting the Jatropha business model, the director of RNI promoted different business models, which did not meet the farmers' expectation to obtain high income from selling Jatropha. It was also selective because it only highlighted the possible benefit of Jatropha development and not its risks.

[25]Kompas, March 18, 2011. "Desa Mandiri Energi bohong-bohongan?"

[26]Transcript of the meeting (February 21, 2007).

[27]Kompas, March 7, 2011. "Minyak Jarak telantar"

[28]Interview with farmer A, August 9th, 2010.

3.3.4 Alienation

In 2005, the Agricultural Service of East Nusa Tenggara sent large tractors to areas that had initially been planted with cashews and replaced them with Jatropha (Vel, 2008). This activity was followed by giving the farmers herbicides to clear weeds in Jatropha fields. However, none of the farmers were told about how to apply the herbicides safely nor did they have information about the Jatropha market. Uncertainty also appeared in West Java, where the farmers started to expand their Jatropha plantation to productive land to gain more income while at the same time the government shifted their policy from growing Jatropha as a cash crop to growing Jatropha for self-consumption (Amir et al., 2008). When I investigated how Jatropha enacted Grobogan actors, I found two separated networks.

The first network refers to the pilot project visited by the President. The main actor in this network was Energi Hijau Lestari, a company that intended to buy Jatropha products from the farmers. According to the head of Sri Rejeki farmer's group, he had a contract with Energi Hijau Lestari that stated their agreement to buy Jatropha from his group. To catalyze Jatropha development, the company also supported the farmers by giving them free seeds. Apart from Sri Rejeki, there were 21 other groups, each of which cultivated Jatropha in 2.5 hectare areas. The director of Energi Hijau Lestari said that the profit came from the zero-waste concept where each part of Jatropha is transformed into different products, e.g., fuel, soap, briquette and medicine. However, when I visited Energi Hijau Lestari in Grobogan in August 2010, I observed that there was no activity remaining in the location. The head of the village told me that the company only operated for a year. He wondered to whom he should address the tax for the factory building, which was built on two hectares of land owned by the village.

To obtain more information about the pilot project, I went to the Agricultural Agency of Grobogan office, where a staff member gave me the phone number of the director of Energi Hijau Lestari. When I contacted the director's number, he did not respond to both my call and text message. I obtained information about Energi Hijau Lestari from the national newspaper, in which the director explained that their company closed down because the government and the state-owned enterprise bought pure Jatropha oil from them very irregularly.[29]After the company closed, the farmers chose to return to their regular jobs of nurturing forest crops and to their main energy source for cooking, firewood.

The second network refers to a new project that was operated using the 10 billion IDR promised by the President. The main actor in this network was Pertamina, the company that managed the 10 billion IDR. At the beginning, the central government handed the fund to the

[29]Kompas, March 18, 2011. "Desa Mandiri Energi Bohong- bohongan?"

district government. However, when I traced the fund to a staff of Grobogan Development Planning Agency who was responsible for Jatropha development, he told me that they could not manage the fund because they needed a special regulation to do it and therefore they returned the fund back to Pertamina.[30] At Pertamina, the fund was used to construct a biofuel reactor, to buy Jatropha seeds and to supervise Jatropha farmers. As a formal body in Grobogan, Pertamina formed a new enterprise named Peduli. In mobilizing the farmers, Peduli asked the existing farmer's groups to write a proposal consisting of farmers' identity cards to indicate their commitment to Jatropha plantations. After the proposal had been approved, the farmers would receive seeds from Peduli. The farmers would be paid for each activity of planting, maintaining and harvesting.

According to a Peduli representative, the first harvest failed due to the poor quality of the seeds. Therefore, in the second plantation, Peduli used seeds from Balitri, a research center for spice and industry crops. This time the Jatropha plant gave fruits as expected; however, the production cost of biodiesel was more expensive than the fossil fuel market price. Despite the expensive production cost, the farmers were also not satisfied with the 1700 IDR per kilogram price adopted by Peduli. The farmers wanted Jatropha to be valued as their initial crop, corn that was worth 2000 IDR per kilogram and required less care. This problem led to detachment between the farmers and Peduli, with the result that the farmers returned to their initial crop and Peduli shifted their energy source from Jatropha to Calopyllum inophyllum.

In this cluster, Jatropha enacted other actors via alienation, which emerged through Jatropha's detachment from other actors. These calculations combined the absence of functionality, utopianism, contradiction and selectivity. The district government of Grobogan, Energi Hijau Lestari, Peduli and the farmers were no longer able to see how Jatropha could benefit them. These heterogeneous actors might have divergent interests but their enactments towards Jatropha were coherent; none of them wanted to be entangled with the crop.

3.3.5 Subalternism

When I returned to scientist C to ask why Jatropha pilot projects had mostly failed, he pointed to scale as the main problem:

> "One of the weaknesses of the government model was its small scale that did not meet the economical scale. A factory with Jatropha area of 1000 hectares consumes ten to fifteen per

[30]When we traced the reason why Grobogan Development Planning Agency handed the money to Pertamina to the Agency, the expert staff who met us said that it was due to the absence of regulation on how to manage the money. Government agencies were not allowed to receive money and thus managing ton billion IDR was illegal (interview with the expert staff, October 14, 2010).

> cent energy from the total energy produced, while factory with area of 500 hectares consumes thirty to fifty percent. If a factory produces biodiesel from area less than 100 hectares, the energy needed to produce biofuel become bigger than its output. I already mentioned this inefficiency to the government, but they would not listen."[31]

Scientist C suggested that the balance between environment, people and profit could only be achieved if people used pure Jatropha oil instead of biodiesel. This strategy allowed people to avoid cost from buying alcohol to make biodiesel. Apart from reducing the production cost, he also highlighted the significance of adopting a biorefinery mechanism by which the Jatropha business would be developed not only for the energy market but also for the non-energy market via processing of Jatropha waste into soap and other products.[32] Some of the scientists I met questioned the method used by scientist C and also his assumptions.[33] They said that these over-optimistic numbers contributed to the failure of translating Jatropha design into material practices.

When I asked the central government to tell their side of the story, they referred to the scientists' over-optimistic numbers of Jatropha productivity as a base for making policy.[34] The coordinator of the energy self-sufficient village program admitted that many Jatropha projects had failed to meet their objective to support local energy needs. She argued that this failure was rooted in the hype of Jatropha as a 'golden' crop. This hype stimulated farmers to plant Jatropha in their productive land while the market was absent. Hence, according to the national government, the failure should not be addressed solely to the government but also to the local initiatives for planting Jatropha based on hype and not on demand. She suggested that Jatropha was only ready for experimentation and not for commercialization.

> "Jatropha initiative came from the idea of utilizing non-edible crop for biofuel. The idea came from the Minister of Research and Technology who at that time (in 2005) saw Jatropha as the most suitable crop to be developed. Its research has been started by BPPT in the 1980s. (Between 2001 and 2007) there were many political and financial supports for Jatropha. However, after many people started to involve with it, we found out that Jatropha was not ready for commercialization. Based on the (laboratory) research, we calculated that Jatropha would produce 10 tons per hectare per year. There was even information saying that it could produce 25 tons. When we tried it on our experiment plot, however, it only produced one ton per hectare per year at maximum. I do not know about the latest research, but Jatropha is still at the experimental phase. We promoted Jatropha as a potential crop for critical land. However, although we never suggested farmers to plant Jatropha in productive land where other crops can live, many farmers shifted their original crop to Jatropha. In response to this situation, we developed a concept of energy self-sufficient village. We were

[31]Interview with scientist C, June 12, 2007.

[32]Ibid.

[33]Interview with Scientist B, October 4, 2010.

[34]Statement from the representative of the Coordinating Ministry of Economic Affairs on a national workshop entitled 'Where Indonesian biofuel are going to be brought?' May 15, 2012 in Bandung.

> hoping that through the new program, farmers would be able to provide their own energy needs."[35]

A similar remark came in the coordination meeting between the central government agencies, Bandung Institute of Technology, Indonesian Biofuel Producer Association and Medco Downstream Indonesia on May 25, 2012. In the summary circulated among participants of the meeting, they acknowledged that farmers preferred to plant non energy crops because it has a stable market. They also noted that cross-institution coordination also created a problem for government's agencies because activities for biofuel involve authorities from more than one department or ministry.

They also admitted that their decision to distribute biofuel processing unit without anticipating the dynamics of the Jatropha supply was a mistake. Therefore, in the conclusion, the participants of the meeting agreed to propose the energy self-sufficient village program, of which Jatropha was a part, as a multi-year program instead of a one-year program so they could supervise the development of Jatropha and other energy crops gradually. Their second recommendation was to allocate funding for field supervisors because the energy self-sufficient village program aimed to change people's mindset on energy consumption behavior and not only to produce biofuel. Despite being attended by representatives of various government agencies, they made a remark on the summary stating that these recommendations might not work because the people who attended the meeting did not have the authority to make a decision due to their low structural (managerial) position. While the collective of government apparatus and the famers decided not to continue Jatropha, or at least decided to put it on hold, scientist C continued his research on Jatropha through his collaboration with a Dutch university. In 2006, he and his partner were awarded a Scientific Programme Indonesia – Netherlands (SPIN) Priority project to research the potential valorization of the Jatropha tree. This collaboration continued until 2013 through their collaborative research and joint publications.[36]

In this cluster, Jatropha enacted other actors by complying with spokespersons' activities to speak on behalf of the crop (cf. Holbraad, 2011 on things). Scientists and the central government tried to escape from their responsibility to address the Jatropha failure by arguing that they had the least connection to Jatropha, that their activities toward Jatropha were mediated by other actors and that other actors did not follow the proposed plan. These activities were performed on the dimensions of functionality, by highlighting Jatropha's potential; utopianism, by highlighting the possibility to have an improved Jatropha, performed through restructuring Jatropha management and re-assessing the readiness of Jatropha as a commercial

[35]Ibid.

[36]I did not put any reference for this information to protect my informant.

crop; and contradictive, by building new fantasies that work on the principle of cooperation, while they escaped from responsibility of the current failure by blaming other actors.

3.3.6 Theory Building

This paper proposes that the process of exclusion and inclusion in innovation performances can be investigated by multiplying the perspective and, empirically, by seeking for multiple sources of action. By classifying the socio-political configuration based on the types of values, I identify actors' activities as being driven by multiple values. The presence of these values suggests that innovation performances were not only driven by the identity or characteristic of the innovation (e.g., good conceptualization, advance) but also by their ability to enroll actors' values. Throughout the analysis, I show that Jatropha innovation in Indonesia followed the values of technocracy, developmentalism, governmentality, alienation and alienation.

Technocracy refers to the values of making decisions based on expert knowledge, rather than political interest, and is often undergirded by scientific experiments. *Developmentalism* refers to specific economic calculations adopted by the government to steer the national policy. It is characterized by top-down planning by the state officials; confidence in developmental solutions provided by Western techno-science; the paternalism of the state toward its citizens and subjects; and a call for increasing socio-economic differentiation in the population (Burton and Jennings, 2007 in Arora et al., 2013; cf. Amir, 2005). *Governmentality* refers to values steering the citizen towards the government's policies by combining the act of governing (*gouverner*) and modes of thought (*mentalité*) (Lemke, 2001 on Foucault). Its purpose is to secure the national welfare, the improvement of its condition and the increase of its wealth, health and others via arranging instruments so that people act as they ought to (Li, 2007). *Alienation* refers to actors' values to take a distance from a thing, which in this paper refers to Jatropha. Subalterns are a group of actors or a configuration that has limited or no access to the existing hegemony (cf. Spivak's interview with de Kock, 1992 on subaltern). *Subalternism* is enacted through activities of speaking on behalf of the marginal (Spivak, 1988). Table 3.2 summarizes the characteristics of the values discussed earlier.

Table 3.2 Characteristics of Values

	Technocratic	Developmentalism	Governmentality	Alienation	Subalternism
Mode of evaluation	Science, expertise	Justice, equality, human right	Governance, control	Detachment, isolation	Representation, authority
Norm	Efficiency	Solidarity	Power	Absence of power	Power

These five clusters are extracted from the empirical materials through a careful analysis of investigating actors' calculations. Table 3.3 shows how dimensions of fantasies appear in these values differently and how the presence of the same dimensions can appear in different values (e.g., technocratic, developmental, governmentality). Please note that this table is not comprehensive and its aim is to provide illustration on how the four dimensions of fantasies can be used together with the concept of values to elaborate innovation performances.

Table 3.3 Values and Fantasies Associated with Jatropha Development

	Technocratic	Developmentalism	Governmentality	Alienation	Subalternism
Functional	(+) Scientists: Jatropha as superior to other crops, suitable for power generation and for cars	(+) Policy makers: Jatropha as able to address poverty problems, to create jobs and to contribute to rural development	(+) The President promised the farmers that the state-owned enterprise would buy their Jatropha	(-) Jatropha was considered as bad for the government of Grobogan, private companies and the farmers	(+)Scientists and the central government try to strengthen their rhetoric by speaking on behalf of Jatropha and its potential
Selective	(+) The scientists framed their rhetoric strategically based on what they see as important	(+) Each actor conveyed their fantasies about Jatropha selectively based on what matters for them	(+) In promoting Jatropha in Grobogan, the President only highlighted the possible benefits of Jatropha and not it risks	(-) The related actors highlighted their loss when attached to Jatropha	(-) The actors highlighted their contribution to develop an alternative energy and, at the same time, to highlight how other parties did not follow the proposed plan
Utopian	(+) Jatropha and the related institutions were assumed to be apolitical and perfect	(+) Jatropha was portrayed as a silver bullet to solve various problems	(+) The President's statement and his presence in the village were translated as a warranty for Jatropha's success	(-) The actors saw uncertainty in Jatropha more as risk than as opportunity	(+) Jatropha still has a chance but only by restructuring the Jatropha management team and the scientists' network and re-assessing the readiness of Jatropha as a commercial crop
Contradictive	(+) The scientists drew resources from actors who supported their approach,	(+) The local government wanted to develop Jatropha by stages and private companies wanted to develop Jatropha at a large scale to increase efficiency	(+) The director of RNI promoted different business models, which did not meet the farmers' expectation of	(+) The related actors did not know who was responsible for what in Jatropha development	(+) The actors build new fantasies that work on the principle of cooperation, while escaping from responsibility of the current failure by blaming other

	Technocratic	Developmentalism	Governmentality	Alienation	Subalternism
	while avoiding discussing details with actors who have different approaches		getting high income from selling Jatropha		actors

(+) refers to compliance of the activity in following the characteristics of fantasy dimensions; (-) refers to incompliance of the activity in following characteristics of fantasy dimensions.

The descriptions yielded a picture of an open-ended innovation process, during which tensions and compromises between acting and being enacted upon are exercised. The table shows that the values of technocratic, developmentalism and governmentality comply with four dimensions of fantasies. These compliances refer not to one type of actor but rather to a set of heterogeneous actors (e.g., scientists and policy makers embody their actions with technocratic values). It also shows that the values of alienation and subalternism do not comply with the four dimensions of fantasies. These findings suggest that actors' ability to include or to exclude Jatropha is determined by both internal Jatropha actions, represented by the notion of fantasies, and external developments, represented by the notion of values.

The analysis shows that for most of the actors, Jatropha was only a means to an end of wider structures such as a means to alleviate poverty for the policy makers, to develop relevant research for the scientists and to obtain alternative income for the farmers. Therefore, when Jatropha was no longer able to enact all of the dimensions of fantasies and actors were able to perform values of alienation and subaltern, Jatropha performances came to an end. In the long run, the enactment of these individual values may threaten future development because they did not solve the common energy scarcity problem.

3.4 Concluding Remarks

This paper attempts to answer a research question on how fantasies of Jatropha impact research and innovation and how actors' values shape Indonesia's biofuel trajectory. By applying an analytical framework that combines dimensions of fantasies and values, I draw the following conclusions.

First, this study contributes to energy research by showing that negotiations between fantasies and values shape the trajectory of biofuel innovation in Indonesia. Changes in the innovation trajectory are visible through the presence of five values: technocracy, developmentalism, governmentality, alienation and subalternism. These values differ in terms of

materializing dimensions of fantasies and the impact on promoting innovations. Because these values are based on a single case study, they cannot be considered general, although I expect that the combination between fantasies and values will be generally valid. This new constructed theory or proposition may advance current understanding in energy research by suggesting that energy scholars should approach innovation as a source of stability as well as change (cf. Feldman & Pentland, 2003 on routines) and that these outcomes are political (cf. Francis et al., 2005; Achten et al., 2010). These findings verify the proposition of innovation performances as being shaped by fantasies and values and the proposition that these performances provide space for change (e.g., biofuel innovation) as well as stability (e.g., means for poverty alleviation, research funds, etc.).

Second, in terms of expectation and fantasies study, the analytical framework contributes to extending the scope of the study by focusing not only on a single perspective of innovation but also on its relation to a different source of actions. Geels and Smit (2000) suggest that future images do not come true because they are based on over-simplistic conceptualizations of technological development and, in particular, anticipate complexity in socio-technical change. By combining the notion of fantasy and values, I have shown that future images did not come true not because they were based on over-simplistic conceptualizations but rather because the actors did not introduce new future images. Therefore, other actors begin to lose interest in the proposed image. Throughout the paper, I have shown that scientist C continued his research on Jatropha by shifting his approach from collaborating with industry to collaborating with research agencies. This action was possible due to his attachment to his scientific network which allowed him to continue to act based on technocratic values. This shifting allowed him to detach from a bad conceptualization to a new configuration that works through the production of new images.

Third, across the five variant of fantasies and values, actors created different relations to Jatropha. These differences show that actors' activities were not dictated by a distant structure that existed out there, but rather that this structure was enacted through endless calculations including or excluding Jatropha, depending on their network. Sovacool (2014) suggests that in different places such as in Bali and Sumatra, patterns of energy use are shaped by people's religion and ethics. This study shows that patterns of innovation performances in energy were shaped by active negotiations between fantasies and values. The analysis shows that the political instability, due to rise of the national oil price, 'forced' the national government to include Jatropha in their activities as a silver bullet to solve multiple problems through one program (see Section 3.2 and 3.3). Once the government overcame the political instability, Jatropha lost its ability to force the national government to mobilize and to enroll other actors to develop it. This

loss appeared clearly from the change in calculation from governmentality to alienation and subaltern, with the result that Jatropha became nobody's crop. This illustration suggests a performance of *power with* (Follet, 1925) where the ability to get others to do things was relational because the government allowed itself to be enacted by Jatropha.

Finally, I want to argue that the strength of the analytical framework proposed in this paper lies not in its coherence but rather in its adaptability to draw contrasts between actors' multiple enactments towards an innovation. It is possible for other innovation cases to have different values. This approach may not be satisfactory for readers who are expecting a single representation of an innovation or are looking for a checklist to diagnose innovation processes. Throughout the analysis, I have shown that the absence of at least one of the dimensions of fantasies contributes in actors' detachment to the innovation and that this detachment was enacted through generating different values. To improve this framework, I see a necessity for future studies to cover cases where innovation succeeds in enrolling actors. These cases are expected to provide an explanation of whether fantasies are only needed at the beginning of innovation or are represented continuously in innovation processes and of the types of calculations that may emerge in a 'successful' innovation.

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4. Nonhumans in the Practice of Development: Material agency and friction in a small-scale energy program in Indonesia[37]

ABSTRACT

We develop the outlines of a new approach to study the role of nonhumans in constituting 'implementation' and calculative-discursive practices in development projects and programs. Developing a conceptual framework built on the concept of *friction* (material resistance or recalcitrance encountered in processes of transformation), we analyze an Energy Self-sufficient Village program in Indonesia. Focusing on specific projects and episodes within this program, we identify multiple distinctive instances of friction. These were driven by nonhumans' (and humans') resistance, as remolding of development beneficiaries' practices was attempted by project administrators, government officials, entrepreneurs and by the (scientific) calculations embedded inside their policies, strategies and models. In concluding, we distill four ways in which nonhumans shape development practices: a) by resisting representations and calculations produced by human actors, b) by re-directing planned/expected courses of action, c) through biophysical change to their weight or textures as they move in space and time, and d) by mediating competition for resources. Overall, nonhumans play a central role in making and unmaking asymmetric relations of power. Their diverse material and discursive agency, which manifests differently in different relational settings, also highlights the importance of broadening the range of spokespersons who speak on behalf of nonhumans and whose voices can be considered reliable and true. Our study thus provides support to calls for pluralizing and democratizing development 'expertise' beyond the usual suspects in science, government and civil society.

Keywords: actor-network theory, practices, relational agency, development policy, sustainable development, agrofuels, bioenergy, Indonesia

4.1 Introduction

In 2006, the Indonesian government introduced the Presidential Instruction No. 1/2006 about the utilization of biofuels where it mandated thirteen ministries, all provincial governors as well

[37] This chapter is a longer version of Fatimah, Y. A., & Arora, S. (2016). Nonhumans in the practice of development: Material agency and friction in a small-scale energy program in Indonesia. *Geoforum*, *70*, 25-34.

as mayors and district heads to support biofuel development. A year later, this instruction was followed by the launch of Energy Self-sufficient Village (ESV) program that aimed to cover at least 60% of the energy demand of 3000 remote villages using local resources. The program was undergirded by calculations of biofuel production potentials generated by scientists and demographic data about poor villages produced by the statistical bureau. The scientists highlighted the promise of new biofuel technology for increasing efficiency of agricultural production and for improving poor people's welfare. The statisticians pointed to the existence of 37.17 million (or 16.58% of the total population in 2006) poor people in Indonesia who lived in 'underdeveloped' villages. Building on these rationales, between 2007 and 2013, a number of ESV projects were initiated. But by 2014, most of these biofuel "self-sufficient village" projects based on energy crops such as Jatropha curcas and Calophyllum inophyllum had been discontinued (Afiff, 2014; Fatimah et al., 2015).

Despite these failures, new biofuel self-sufficient projects using different energy crops were continuously being promoted. For example, in March 2015, the provincial government of West Kalimantan issued a call for cultivating an energy crop named *Kemiri Sunan* (Reutealis trisperma) (Kompas, 9/3/15). This call was preceded by activities of planting 12,300 *Kemiri* seeds in 5,000 hectares area owned by local farmers. A month later, actors from the Ministry of Energy and Mineral Resources, the state oil company and Bogor Agricultural University held a workshop on using Kemiri Sunan to rehabilitate degraded land. In this workshop, these actors justified their support for Kemiri Sunan due to its potential of growing on marginal lands, carrying high oil content, a 100 year life-span and a possibility to work as a fertilizer (Antara, 16/04/15). These great expectations were strikingly similar to claims made by the previous Indonesian president Susilo Yudhoyono when opening the Jatropha-based self-sufficient village project in Grobogan in 2007,[38] and by Minister of Forestry when he inaugurated the Calophyllum-based self-sufficient village project in Purworejo on 2009.[39] Biofuel Self-sufficient Village projects were then, as now, expected to meet energy demand within the village while creating jobs and alleviating poverty. However, the biofuel crops and machines in the projects, by not performing the roles assigned to them, often despite the projects' human participants best efforts to make the projects succeed, were critical in constituting project practices and outcomes that were far removed from the governments' (and the scientists') expectations.

In this paper, we argue that practices in and outcomes of development projects can be better understood by appreciating the role played by nonhumans in transforming idealized

[38] Transcript of dialog between the Sixth President and Grobogan farmers, February 21st, 2007.
[39] Masyhud, the Ministry of Forestry press release, December 4th, 2009.

expectations of project administrators, their expert advisors and funding bodies. Nonhumans, just as humans, do not always play roles that are assigned to them by other powerful actors, but rather they may display recalcitrance toward plans and expectations of the powerful. While we study projects that were not funded by international development aid, but rather by the Indonesian government, we believe that our analysis of the role of things in development practices has conceptual and methodological implications for studying practices in any development projects that involve technological or ecological elements.

In the last two decades, a significant body of literature in development studies has turned its attention to the actual practice of programs and projects during their implementation (see for example, Pigg 1995; Li 1999; Tsing 1999; Mosse, 2004; 2005; Lewis and Mosse, 2006a; Bebbington et al. 2007; Heeks & Stanforth, 2014; Ponte, 2014). Scholars have studied how, a) different subjectivities (e.g. as 'indigenous practitioner', 'community elder' or 'subsistence farmer') are re-constituted within development practices (Pigg 1995; Li 1999); b) practices are enacted through activities of convincing and enlisting heterogeneous actors as participants in a project (Tsing 1999; Mosse 2004); c) how different sets of practices ('social, discursive, and political') come to co-exist under different organizational cultures and under top-down and bottom-up strategies for project organization (Lewis and Mosse 2006a; Bebbington et al. 2007; Ponte, 2014); d) how a project's evaluation as success or failure depends on the interpretation and representation of actual project events through discursive practices informed by policy models (Mosse 2004; 2005; Rottenburg 2009; Heeks and Stanforth 2014).

Surprisingly, however, apart from development policies and the models undergirding them, this literature has given little attention to nonhumans as active constituent elements of development practices. Nonhuman action has been studied more extensively in science and technology studies (STS) (e.g. Callon, 1986; de Laet and Mol, 2000; Shepherd and Gibbs, 2006; Law & Mol, 2008), animal geography (e.g. Philo, 1995; Buller, 2014), and archaeology (e.g. Malafouris 2013; Witmore, 2014). This work has shown that nonhumans are not simply pliant objects, which human actors can willfully control (manipulate and measure), but rather they try to resist control by human actors, and have to be interested and manipulated in order to instead act as the humans' allies in action. In this article then, we conceptualise action as distributed across a range of associated humans and nonhumans. Such a distributed conceptualization of action permits the possibility of nonhuman resisting the roles assigned to them by human actors at any time, even after they have been interested and aligned. It also allows us to extend the repertoire of pragmatic investigations into development, which becomes an effect of network of humans (with their dispositions, thoughts and bodies) and nonhumans (with their materiality in

the form of weights, shapes and textures as well as the visions and knowledges inscribed into them). Introduction of a new entity into the network will, in general, require the adjustment of the network's other constituent entities (and the relations between them) to the new entity and vice versa. This multi-entity adjustment is unlikely to be smooth, and some entities may pose resistance to adjustments. We conceptualise this resistance and recalcitrance posed by nonhuman and human entities in a network as *friction*. Friction is emergent and its sources cannot be fully predicted. Such a conceptualisation allows us to avoid imposing any *a priori* coherence on development projects, despite the presence of 'coherent' policy models that ostentatiously govern these projects and their practices.

In the remainder of this article, we review relevant literature in development studies, focusing on accounts of practices and the role played by nonhumans in these accounts. This is followed by a theoretical section in which we develop our conceptual framework, following which we briefly discuss the methodology of our fieldwork in Indonesia (carried out by the first author between 2010 and 2012). An empirical section then recounts episodes of friction in four different hybrid collectives constituted at various times in the ESV project. Finally, a set of conclusions are drawn about the new insights offered by the inclusion of nonhumans into the analysis of development practices.

4.2 Practices in Development

In the last two decades, the discipline of development studies has turned its attention to the study of practices. The first such studies of practices were carried out by critical scholars who argued that development policy was nothing but a passage for the exercise of asymmetrical power (see for example Escobar, 1995; Sachs, 1992; Ferguson, 1990). These critical scholars aimed to unmask unequal power relations and domination hidden underneath the rhetoric of rational policy-making and planning. But domination is anything but straightforward. Introducing an edited volume on the anthropology of policy, Shore and Wright (1997) argued that while policy may *attempt* to dominate and constitute subjectivities, its making and implementation entails contestation between heterogeneous actors. This argument foregrounds that, unlike the claims made by early critical scholars, development policy is not a homogeneous or absolute tool of domination, but rather its power is operationalized through a struggle between different interests, identities and interpretations. Such a conceptualization is consistent with a focus on practices in which power to dominate is a contingent outcome of actors' relations with others but not a property of actors in themselves (Donovan, 2014; Ernston, 2013;

cf. Callon & Law, 1995). Viewing power as negotiated and relationally distributed allows one to escape the critical assumption of development as a set of practices to objectify and homogenize the worlds of its 'beneficiaries'. In the following, we provide an overview of the literature on development practices, produced largely by anthropologists, focusing on how this literature has captured the role of nonhumans (living beings, technologies, models, concepts and statements) in practices.

Path-breaking critical work on development practices was carried out by Ferguson (1990), who discusses how the national government in Lesotho, by implementing a large international development aid project, expands the scope of its bureaucratic power over its citizens. Ferguson's detailed ethnographic work shows that the building of the road to connect Thaba-Tseka district with the capital city allowed the national government to exercise stronger administrative control over the region. This outcome was rather removed from the main rationale undergirding the project i.e., the development of a commercial livestock industry in the Thaba-Tseka region. By emphasizing this rationale, according to Ferguson, the central government of Lesotho was able to represent the project and their administrative apparatus as being situated outside the realm of politics, thereby 'depoliticizing development' (see also Bebbington 2005; Büscher, 2010). A substantial literature has provided evidence to support Ferguson's idea that development (aid), instead of generating the common good it rhetorically promises, ends up producing and furthering bureaucratic control and interference in the lives of its purported 'beneficiaries' (see e.g. Scott, 1998; Anders, 2005; Gould, 2005; Yarrow, 2011). While highly influential, and largely consistent with other critiques of development coming out of the so-called post-development literature (e.g. Rahnema and Bawtree 1997; Escobar 1995), this view has also been persuasively criticized for allowing little room for the (heterogeneity of) agency of development's 'beneficiaries' beyond that of resistance (Everett 1997; Fletcher 2001; Mosse 2004).

Ferguson's pioneering work also provided an impetus to the stream of scholarship on the relationship between development discourses and actual practices on the ground in specific projects and programmes. Ferguson had argued that development policy discourse, once it is materialized into actual practice, provides a passage for accumulating power in the hands of the powerful. Such an account inevitably ends up demonstrating the domination of one group over others (Mosse 2004; Jensen and Winthereik 2013). While asymmetry in inter-group relations may be common, the production of domination needs to be demonstrated, as indeed Ferguson does. However, in his narrative the production of domination is a straightforward process where any development models (and other discursive and material entities such as roads and administrative

centres) simply play the role that the powerful desire from them. Thus, nonhumans instrumentally help some human actors gain dominance over others *in practice*.

A more nuanced examination of how development may benefit, and how it may be appropriated by, elite organizations and local populations (in different ways) is carried out by Li (1999; 2007; also see Lewis & Mosse, 2006a; Simandjuntak, 2012). Li (2007) extends the work of Ferguson (1990) and Escobar (1995) by moving beyond the domination-exploitation framework, conceptualizing governance as a hybrid process in which acquiescence (of development's beneficiaries) plays a role alongside bureaucratic control (by national and provincial development administrators). By including this heterogeneity into her analysis of practices, she is able to show how different groups of actors mobilize resources to govern, to comply and to resist. While development administrators may benefit by extending their bureaucratic control, as Ferguson argued, this does not directly imply that the 'beneficiaries' are only exploited and that there is no room left for them to tactically 'consume' development in ways that were not intended or planned by the administrators (Mosse 2004: 645-46). Such a space for beneficiaries' agency is argued by Li and Mosse to be a product of the vulnerability and fragility of policy models or bureaucratic plans in practice, which are only 'secure on paper'. However, even in this understanding of development practices, which are only partially controlled by powerful humans, nonhumans such as development models and plans are considered too weak to shape actual practices.

Other nonhumans such as houses enter Li's (1999) accounts as passive entities that sustain some humans' interests and routines. In Li's narrative about a resettlement program of the Indonesian government, houses are represented as props that can be used to support the argument that the program has failed because "the houses are left to rot or are taken over by other villagers", which was not desired or expected of the program (1999: 301). Here, Li places houses only in *relation to the program's stated objective* of delivering 'ordered' housing to 'isolated [indigenous] communities', which is then considered to have failed in achieving this objective. Such an emphasis ends up situating things such as houses (Li, 1999), and identity cards in the study carried out by Simandjuntak (2012), as governmental devices deployed by administrators to develop human 'beneficiaries'. If things play the role ascribed to them by development administrators, they are deemed successful and they make a project or program successful. And if they do not behave as expected, the things are argued to fail and so does the project/program they are part of.

Focusing on practices of representation within development projects, Mosse (2004; 2005) argues that many actors play a role in maintaining coherent representations of a project's

actual events/activities in accordance with its policy models, in terms of what the donors desire and expect to achieve, obscuring the disjuncture that exists between the representations (including policy documents and project reports) and project implementation practices (see Lewis and Mosse 2006b). The effects of donors' expectations and policy models are limited to this 'report generation' and may not influence the actual implementation of a project (Mosse, 2004; 2005).[40] The latter is instead driven by local social relations (including the patron-client type of relationships that may develop between administrators and 'beneficiaries'), by the routines of implementing organizations and by the beneficiaries' creative and tactical ways of using development. While foregrounding this local embeddedness of development practices and focusing on the production of representations, Mosse's detailed narrative does not illustrate how nonhuman material entities (such as lands and farm-inputs) play a role in shaping these representations and constituting actual implementation practices on the ground.

Mosse (2004; 2005) did emphasize the role of policy models such as participation that work as 'mobilizing metaphors', bringing not only actors with diverse interests under the umbrella of a development project but also secure the necessary development funds for implementation (also see Rottenburg 2009 on the similar role played by development plans and contracts which he calls inscriptions). Following Mosse's influential work, recent studies by Singh et al. (2014) and Pradhan and Ruysenaar (2014) have emphasized that (successful) policies work through their ability to include a heterogeneous group of actors as supporters but not necessarily by reaching their stated and desired objectives (including the desired 'best' practices). Similarly, focusing on irrigation management transfer in Mexico, Rap (2006) shows that a policy model becomes widely implemented and successful by aligning as many disparate social and material entities with it as possible. Yet, while documenting the model's promotion by powerful human actors and through the use of digital/visual means of representation (of the model's local successes), Rap does not document how materials such as irrigation canals and the water flowing through them act in affording the model to extend in space and time. Overall, in these studies as in Mosse's work, the only nonhumans endowed with the capacity to constitute (discursive) practices are policy models and statements, which are produced by authoritative human actors and whose goals and desires the models/statements instrumentally serve. Other nonhumans such as material biophysical and technological artefacts do not enter the picture as entities that actively constitute development practices.

[40] It is also in this sense that the policy models are fragile in the practice of actual implementation of a project.

Related work on the performativity of policy models is carried out by MacDonald and Corson (2012). They argue that a policy model or concept (in their case, 'natural capital') is true not because it represents reality accurately but rather because it contributes to the making of the reality it describes. Through their ethnographic work on The Economics of Ecosystems and Biodiversity (TEEB) project, they document how the policy ideal of natural capital formats arrangements for circulation of information about and for calculating the value of nature. However, despite promising to include material resources and technologies alongside discursive factors, their analysis falls short of documenting the material (technological or ecological) transformations produced by the policy model in question. Unlike Macdonald and Corson's study, Rottenburg's (2009) fictionalized ethnography, focusing on development practices in what he calls "interstitial spaces" that are neither the locations in which a theoretical or policy model of development originated nor places where it is implemented, documents how representations (reports, monitoring data) generated in development projects do not only describe the reality of the projects but play a (performative) role in producing a reality (see also Rottenburg 2014). This reality is created in development projects that attempt to alter the "cultural practices" of their beneficiaries in fields such as agriculture (often the landless or smallholders) and healthcare (Rottenburg 2009: xx). It is also obviously created in projects to build public infrastructures such as telecommunication networks, roads and bridges.

Other work on development policy-practice relationships has used the concept of translation from actor-network theory (ANT). Translation refers to the process of enrolling heterogeneous entities into a hybrid network in which one set of spokespersons can eventually speak on behalf of other associated entities (Callon 1986; Latour 1990; Latour 2005). Focusing on indigenous and environmentalist groups' resistance to and alliances with a multinational mining company in New Caledonia, Horowitz (2012) argues that different actors build alliances with others only to achieve their own individual goals. Although these goals may be adjusted over time, the different actors' interests may never become fully (and permanently) compatible with each other. This incompatibility may eventually result in the termination of alliances.

Veldwisch et al. (2009) and Heeks and Stanforth (2014) use the concept of translation to develop a model of power. In this model, power is defined as an outcome of a set of activities of enrolling, circulating and mobilizing other actors. Using this model of power, and viewing development projects as chains through which policy models and data are passed from 'global' to 'local' levels, they attempt to document a series of translations as political processes based not on controlling other humans but on persuading them. However, while theoretically recognizing the importance of nonhuman action, these studies do not account for the active roles played by

nonhuman materials (technological artefacts and natural entities) in the process of enrolling and persuading human actors. And while theoretically recognizing that actor-networks are collectives (that enact practices) constituted by things and humans, in their empirical narratives, these studies still only document how a network of human actors 'implements' things that themselves appear to exist outside of the network. Even in brief accounts of nonhuman action, for example in Heeks and Stanforth (2015: 45), nonhumans only work for the powerful among human actors. Still other uses of actor-network theory focusing largely on techno-scientific practices within 'developing countries', yet largely published outside development studies, allow their bush-pumps (de Laet & Mol, 2000), mosquitoes and dams (Mitchell, 2002), cows on a dairy farm (Shepherd & Gibbs, 2006:683), roads (Dalakoglou, 2010), prepaid meters (von Schnitzler, 2008), water supplies (Anand, 2011), birds (Fearnley, 2013; Rodríguez-Giralt, 2015), cash/audit techniques (Maurer, 2012; Jensen & Winthereik, 2012; Donovan, 2013), to actively enter the frame of action as well as transform it. Here we provide a brief overview of some emblematic studies from this literature, which help us lay the foundations for our own theoretical discussion in the following section. De Laet and Mol (2000) emphasize the material flexibility of the Zimbabwe bush-pump type-B, which is easily re-designed to be adapted into different local settings. This fluidity is nurtured by the developer of the pump who abandons control over the pump's design (and use) in favour of allowing people in different settings to adjust the bush-pumps according to their needs, to the local tools at their disposal and to physical availability of water. In this process, users in different localities also develop the skills to maintain their pumps, giving rise not only to an unexpected multiplicity of Zimbabwe bush pumps but also users. In his illustration of how things may act, Mitchell (2002) studies how the project to dam the Aswan river enabled mosquitoes to jump from one region to the another. Designers (or engineers) of the project had not considered how the project might stimulate movement of mosquitoes and snails, which triggered the spread of malaria and *schistosomiasis* (a parasitic worm infection carried by an aquatic snail). In this way, Mitchell demonstrates the agency of mosquitoes and snails, alongside that of engineers and dams, and their effect on the actions of those who were affected by the diseases that spread.

More recently, Mitchell (2011) has studied how coal mines and cargo-boats, along with the miners and other workers, and technologies of oil extraction and movement from Saudi Arabia to the Mediterranean, afforded democratic struggle (strikes and revolts) in different ways due to the very materiality of their production and transportation chains**.** Shepherd and Gibbs (2006) show that a model dairy farm (transferred from Australia to East Timor) is performed through elements such as lactose intolerance tests, cows, tractors, weeds, human workers and

milking machines. These elements, if not adjusted to one another in specific settings, may resist acting together as a collective (Callon 2007). Furthermore, even after the elements of a collective have been adjusted to each other in one setting (e.g. an Australian rural area), its move to another spatial setting will entail newer adjustments, not only among the entities that are being moved but also with/in the local milieu that is receiving the entities. Thus the transfer of a technology is not simply an undisturbed movement from one setting to another, but rather a process involving resistance by and transformation of the entities that move and of the host entities that receive. As Shepherd and Gibbs (2006:684) document, "seeds, weeds, and cows resisted the control of humans, just as humans resisted the control of nonhumans." Obviously Shepherd and Gibbs do not claim that seeds, weeds, cows and humans resist in the same way. Instead, the nonhumans and humans contribute to acts of resistance, and any other acts for that matter, differently. In the following, rather than attempting to theoretically categorize the difference between actions of humans and nonhumans as if they belong to distinct "ontological regions" (Vandenberghe 2002: 53), we will attempt to empirically map the differences between the actions of different humans and nonhumans. Thus, our theoretical discussion below is limited to the conceptualization of distributed action, between humans and nonhumans who form hybrid collectives that act, and frictions encountered in the process of assembling the collectives that act.

4.3 Capturing Nonhuman Action

To conceptualize the active role of things in development, following some of the studies reviewed above, we develop a relational approach to the agency of humans and nonhumans. Characterizing agency broadly as action that makes "some difference to a state of affairs" (Latour 2005: 52), we argue that it is an outcome of relations between differently-placed humans and nonhumans. Any act then is an emergent effect of relations between humans and nonhumans, and (non)human actors' "competence is deduced from their performances," (Latour 2004: 237), rather than being solely an effect of humans' intentions or their own inherent capacities (Latour, 1994). In fact, an individual human's capacity to act, and her/his intentions, are not her/his own essential attributes (as claimed for example by Vandenberghe 2002), but rather are constituted through relations with other humans and nonhumans. The latter make individual capacities and intentions possible. For example, a farmworker is only able to act, or function on the farm, with help from associated humans and nonhumans including her tools, the employment contract with the farmer, the crops she may be harvesting or the weeds she may be removing. She, who is apparently an individual, acts as a collective and each of the entities involved in this collective (including the human worker, the tools, and the crops or weeds)

participates in the action of the collective. Thus, even when it appears to be centered on an individual (e.g. a farmer, a policy-maker or even a policy model), agency is instead *distributed* across a range of human and nonhuman entities that together form hybrid collectives (Callon and Law, 1995; Callon, 2008).[41]

Action then, including the making of a development policy, is performed by a hybrid collective (Callon 2008; 2007). Policy-design hybrid collectives are often composed of calculative agencies of economists and their models as well as of other technoscientific experts and their equipment (cf. Callon and Muniesa 2005). In actual development projects where a policy is 'implemented', the hybrid collective that designed the policy may need to be moved into the location of the project. Often, however, such a transportation of entire collectives is not possible, nor may it be considered desirable (as in some community-driven development where local decision-making and control of projects is key: Mansuri and Rao 2004). Fortunately, things such as policies and models 'last longer than the interactions that formed them', and can be (partially) detached from the hybrid collectives that constituted them (Callon & Latour 1981 in Sayes 2014:137; Callon 2007). Even after detachment however, the calculative agencies that constitute an individual policy model will remain embedded in it.

In most development settings then, a policy as an entity is *translated* into a place of implementation. In our relational approach, any place of implementation is composed of hybrid collectives that are already present in 'beneficiary' communities and practices. Translation of a policy into the 'beneficiary' hybrid collectives entails adjustments of the policy (model) for it to work and to be put to work. It also entails a reconfiguration of the 'beneficiary' collectives, through a transformation of their constituent entities and the relationships between these entities (Arora et al. 2013). This reconfiguration may take place differently in different collectives that then enact a multiplicity of practices within a single project (or 'beneficiary' community), undergirded by a single policy model such as participation or self-sufficiency. Thus practices are performed differently in different beneficiary collectives (e.g. on farms, shops, and households), depending on the collectives' human and nonhuman composition.

Translation, as the reconfiguration of 'beneficiary' collectives and the parallel adjustment of policy models into them, is never a straightforward process. It is perfused with *frictions* (cf. Tsing 2005), which are a result of (material) resistance by human and nonhuman entities to the courses of actions attempted, according to others' proposals, plans and expectations (cf. Latour

[41] Recently, in an important intervention, Appadurai (2015) has conceptualized these entities as 'mediants' which are not 'whole individuals' but rather 'dividual beings'. Mediants, in interaction with each other, then constitute practices of mediation of which materiality and human subjectivities are emergent effects.

1988). Resistance (or recalcitrance) as a term can be replaced by a "whole collection of verbs and adjectives, tools and instruments, which together define the ways of being real. We could equally well say "curdle", "fold", "obscure", "sharpen" and "slide" (Latour 1988: 159). Resistance is then a force (of varying strengths and shapes) that changes the course of action to different degrees, depending on the entity in question and the collective in which it resists. Like all action, resistance by an entity is an emergent effect of its relations with other humans and nonhumans.

In general, resistance as friction slows things down, forces changes in direction, and may eventually lead to 'failed' projects if little resemblance is achieved between the projects' stated objectives and the practices (and outcomes) that are actualized on the ground. However, as demonstrated by Mosse (2004), classification of a project as a success or a failure also depends on how the actual material practices are represented in project reports and evaluations. The production of these representations may entail their own resistances, negotiations, and thus frictions (e.g. when a beneficiary's precarious situation resists claims of purported gains delivered by a livelihoods project). Similarly, friction may also be encountered in the process of designing policies by calculative collectives, as outlined above. Thus, friction refers not only to the material resistances that govern the process of policy 'implementation', but also to the resistance encountered by project administrators in producing official representations of actual development practices in line with the policy models.

Following from above, the focus in our empirical analysis is on social-material frictions experienced in translation of policies into four different 'beneficiary' hybrid collectives involving energy crops in Indonesia.

4.4 On the Field

The narratives we present below, informed by the above framework on the role of 'things in development', is based on formal policy documents, newspaper articles and ethnographic fieldwork in Indonesia where the first author studied a government program called the Energy Self-sufficient Village (ESV) from October 2010 to May 2012. At the beginning of the fieldwork, the aim was to investigate a Jatropha biofuels ESV pilot project in Grobogan district. However, by the time of the field visit, the village cooperative running the ESV pilot project had shifted their energy crop from Jatropha to Calophyllum. In June 2011, this cooperative stopped producing biofuels altogether and chose to focus on corn for food rather than Calophyllum for biofuel. This situation left us with two options: to stay in Grobogan and investigate why they stopped producing biofuels or to switch fieldwork location to investigate biofuel activities in Purworejo. Since our primary focus was on biofuel practices, we chose the second option.

The ethnographic work was multi-sited because we followed our informants and associated things as they moved from one place to another. For example, the Calophyllum seeds moved from the forest to the pickers' houses to a biofuel processing factory in Purworejo area, while a local entrepreneur often moved from Bantul district to Purworejo district to Jakarta (e.g. to attend a meeting with central government officials). In moving from one place to another, the aim was not simply to be as close to the informants as possible, but rather to map our informants' relations with others beyond any spatial boundaries (cf. Marcus, 1995, 1999; Hine, 2007).

The ethnographic field notes were combined with our readings of policy documents and newspaper articles to compose a narrative of multiple hybrid collectives (of humans and nonhumans) that were formed at different times, in different places. We present the formation of these collectives by narrating four different episodes of friction (encountered during translations in the reconfiguration of the collectives).

4.5 Frictions in Practices

The first of the four episodes focuses on frictions between calculations led by the Ministry of Forestry to develop a non-forest crop for energy and attempts to promote non-forest crops in the field by the Ministry of Agriculture. The second episode focuses on changes in policy models of energy crop development due to resistances posed by materials or things constituting existing practices in the field. The third episode focuses on frictions due to disagreements in deciding the course of proposed and future changes in the collective calculative agency embedded in the policy models. Out of the latter, different human actors tried to strengthen their rhetoric by framing things (such as energy crops) as supportive of their own interests. The fourth episode focuses on friction between the distributed agencies of the pickers and the crop buyer due to weight change in the crop as it moved in time and space, and in deciding which scale should be used to measure the crop's weight.

4.5.1 Friction #1: Crop or Tree?

In preparation to meet the Parliament in February 2003, researchers affiliated to the working group of Natural Resources of the Indonesian Biodiesel Forum prepared an argumentative document. The document highlighted the Ministry of Forestry's interest on Jatropha curcas development due to the following reasons: i) the plant can be planted in marginal lands with nutrient-poor soils; ii) the plant is suitable for conservation purposes and for use as an energy crop; iii) it is suitable for industrial forestry; and iv) its cultivation can create a multiplier effect for farmers' welfare because it has many potential by-products (e.g. inputs for making fertilizer

and soap).[42] It was expected that the Ministry of Forestry will be able to take the lead in Jatropha development, providing Jatropha seeds to various stakeholders including farmers. It was also expected to develop technology to process Jatropha seeds into biodiesel. Thus, in early 2003, Jatropha was predominantly considered to fall under the jurisdiction of the Ministry of Forestry. This was agreed upon by a representative of the Indonesian Association of Forestry Businesses at the February 2003 meeting with the parliament. Jatropha was argued to belong to the realm of trees by the forestry industry.

However, once the Jatropha promotion work gained some momentum in 2006, most Jatropha-related research and pilot projects in villages on Jatropha curcas were undertaken by the Ministry of Agriculture. In that year, the President issues his Instruction Number 1/2006 that mandated the Ministry of Agriculture to support the provision of seeds and seedlings of energy crops (to farmers). The Ministry of Forestry was to only manage the permissions to use non-productive forest lands for biofuel plantations. The Ministry of Agriculture translated the mandate by planting Jatropha nurseries in 14 provinces and by introducing a new variety of Jatropha. Further, they promoted Jatropha as a plantation crop that could be cultivated together with rubber, vanilla, cacao, coffee and pepper (BPTP Lampung, 2009). Meanwhile, Ministry of Forestry shifted its research to a new energy crop that was classified as a tree, called Calophyllum inophyllum. The Ministry's association with the tree had started in the 1950s when they planted Calophyllum along the southern part of coastal Java as a windbreaker (Bustomi et al., 2010). This association put the Ministry of Forestry in a stronger position than the Ministry of Agriculture, in relation to Calophyllum.

Thus the Presidential Instruction (1/2006) led the Ministry of Forestry to dissociate from Jatropha and, at the same time, associate with Calophyllum. The Instruction thus helped constitute two different hybrid collectives, in which materiality of the biofuel feedstock played an important role: Jatropha's material characteristic of a bush that can be cultivated as a plantation crop allowed it to join the Ministry of Agriculture's collective, while Calophyllum's as a tree that grows in forested areas allowed it to become a part of the Ministry of Forestry's collective. These two collectives were supported by the Ministry of Energy and Mineral Resources and the Coordinating Ministry of Economic Affairs, which cooperated with the Ministry of Agriculture to develop Jatropha in 24 provinces in the Energy Self-sufficient Village (ESV) program and with the Ministry of Forestry to develop Calophyllum inophyllum in two provinces. The Ministry of Forestry collective was joined by Trakon, a manufacturing company, to develop a biofuel processing unit.

[42] Document of the preparation materials for hearing with the Parliament (Indonesian Biodiesel Forum, 2003).

In this episode, friction in the process of formation of the Ministry of Forestry's hybrid collective around Jatropha was driven by the plant's materiality as a 'bush'. This 'bush' resisted its classification by the forestry industry as a type of tree, and thus reshaped the direction of the expected course of action for the Ministry of Forestry. This Ministry eventually did not develop a Jatropha programme. Instead it focused on Calophyllum. On the other hand, Jatropha's materiality as a 'bush' and a suitable plantation crop afforded the formation of a hybrid collective centered around the Ministry of Agriculture. This hybrid collective (composed of Jatropha plants, local government departments, farmers, firms and processing machinery etc.) was also co-constituted by a Presidential Instruction and by various other Ministries, allowing the Ministry of Agriculture to mobilize a wide range of support to develop Jatropha. The development of the Ministry of Agriculture's hybrid collective forced the Ministry of Forestry to search for and develop their collective around an alternative crop that is publicly categorized as a forest tree. Thus, in this episode, frictions manifested not just in the formation/continuation of this latter collective but also in the form of competition for resources, such as Presidential endorsement and wider governmental support, between two different collectives that were assembling at the same time.

4.5.2 Friction #2: National versus Local Calculations

In 2008, the Ministry of Forestry published a book titled 'Calophyllum as biofuel source' in which it argued that Calophyllum was suitable for biofuel production because it: a) is widely available in Indonesia; b) is easily planted; c) has a higher yield (20 ton per hectare per year) than Jatropha (five ton per hectare per year) and oil palm (six ton per hectare per year); d) does not compete with food. In addition, most parts of the Calophyllum tree have economic value and the trees can simultaneously serve other functions such as wind breaker in coastal areas. This book transformed the materiality of Calophyllum into numbers (e.g. based on yield calculations), and then into a business model for pilot projects in three villages, one each in Kebumen, Banyuwangi, and Purworejo districts. These districts were selected by the government due to existing Calophyllum vegetation in the areas. The business model posited that four kilograms of Calophyllum fruit can produce one liter of biofuel and that Calophyllum fruit can be harvested three times per year and sold at 1100 IDR per kilogram (FORDA, 2008). Based on these calculations, each ESV pilot project aimed to provide additional income to the rural poor through the collection and sale of wet Calophyllum fruit.

To understand the business model's translation into actual (material) practices, we focus on the pilot project in Purworejo district (Patutrejo village). According to a local farmer, this process began in earnest when the firm Trakon entered the village in 2008 to install biofuel

processing machines, approaching her (and other villagers) to collect Calophyllum fruit. This installation of biofuel processing machine, together with preparation of seedbeds and planting of Calophyllum, as well as the provision of technical training to farmers so they can operate the machine, was funded by the national budget of the Ministry of Energy and Mineral Resources.

The Minister of Forestry Zulkifli Hasan visited Purworejo in 2009 to formally open the biofuel processing unit and to legally hand over the ownership of the unit to a village cooperative. During the opening ceremony, Hasan said that success or failure of these pilot projects, in Purworejo, Kebumen and Banyuwangi would be used to decide whether the same business model should be replicated in other villages or not. He said that his ministry would assess whether this project is economically profitable for farmers. However, he also made it clear that "economic calculations" aside, his government wanted "to introduce energy crops due to the limited availability of fossil fuels."[43]

In a national ESV meeting held on May 5th (2010) in Makassar, the head of Agricultural and Forestry Office of Purworejo described their involvement in Calophyllum ESV project since 2009 when, together with *Wana Lestari*, a village forestry cooperative, they planted 2000 Calophyllum trunks on common land (*tanah bengkok*) and on an area of around fifty hectares that was used for mining in the past. When they evaluated the state of these trees in March 2010, they found that 90.92 per cent of the trees had grown as expected (Sumarno, 2010). However, instead of producing 1 liter of biodiesel from 4 kilograms of Calophyllum fruit, as the national calculations (and their business model) had predicted, they only managed to produce 60 liters of biodiesel from 750 kilograms Calophyllum fruits in Purworejo i.e., 1 liter from 12.5 kilograms of the fruit. Due to this resistance by Calophyllum fruits against national calculations (and the course of action planned on the basis of these calculations), and perhaps by biofuel production machinery and chemicals which also did not work as expected, the ESV program in Purworejo ended up abandoning biofuel production for a year. Despite these frictions, the ESV project was still considered as a *success* by the national government: "the project had met its physical target by installing machines, planting Calophyllum and implementing in the training." (Uripno, 2015:51).

The disjuncture between the national government's assessment (as a success) and the frictions experienced at the local level (and the one-year hiatus) in the project led to calls for renewal. A senior official in Purworejo's Forestry and Agriculture Office tried to revive the biofuel production unit by seeking help from an entrepreneur from Yogyakarta. The senior official's cooperation with the entrepreneur stimulated the emergence of a new hybrid collective that was successful in mobilizing political support from local organizations including a

[43] Kompas, December 9th, 2009. "Mencoba Nyamplung di Tiga Desa."

Watershed Management Center, the State Owned Forestry Enterprise (Perhutani) and the NGO Relung. In December 2011, a working group for Non-Timber Forest Products was established, involving the actors mentioned above, which formed the basis for the assembly of a new collective for local Calophyllum development in Purworejo.

While the original ESV collective under village cooperative's (*Wana Lestari*) management focused on implementing the national Ministry of Forestry's business model, the new collective around the entrepreneur envisaged a future for Calophyllum oil in the non-energy market. The entrepreneur brought in new machines and two of his trusted workers from Yogyakarta to Purworejo. He reorganized the management structure of the ESV cooperative by making *Sinar Bhineka*, the entrepreneur's firm, a shareholder. As an active shareholder, *Sinar Bhineka* became responsible for funding biofuel activities in Purworejo. According to the entrepreneur and a worker of the ESV cooperative, regular demand was expected from *batik* producers who used Calophyllum oil to dye their fabrics. This demand, however, turned out to be insufficient for maintaining the continuity of the ESV cooperative since the *batik* producers needed only about 75 liters per month while the ESV's production capacity was 100 liters per day. Here the friction encountered by the entrepreneur's planned course of action does not appear to be generated by resistance from a human or nonhuman entity (or even from the practice of *batik* production) but rather it may be argued to be an outcome of miscalculation (overestimate) of market demand by the entrepreneur's hybrid collective. To extend this point beyond this particular case, one may argue that many, if not all, instances of material resistance/friction are simply a consequence of wrong calculations, bad business models, and misguided plans. We address this important caveat concerning the validity of our frictional narratives in subsequent sections of the article.

To utilize their production capacity of 100 liters per day, the ESV cooperative, through *Sinar Bhineka*, tried to expand the Calophyllum market. In March 2012, they conducted a Road Test where they used Calophyllum diesel to fuel three cars for a 730 kilometer journey through Purworejo, Kebumen, Cilacap, Semarang and Yogyakarta. In Purworejo, Kebumen and Cilacap districts, large ceremonies (attended by high-ranking district officials) were organized to welcome the Calophyllum Road Test team. This Road Test was financially supported by State-owned Perhutani. Support for the Road Test from local governments and mass media publicity definitely played in a role in the forestry research and development agency's decision to buy all Calophyllum oil produced by the ESV cooperative for three months. The agency also then demanded Calophyllum seeds from other areas in Java.[44]

[44]http://regional.kompas.com/read/2012/03/05/21221878/Purworejo.Produksi.6.000.Liter.Biodiesel.Nyamplung (accessed 10/25/2013)

In this episode, the first friction was encountered when, by yielding less than a third of the oil promised by the central government's calculations, Calophyllum fruits resisted the calculative agency and the course of action planned by the government and its advisory experts. This friction encountered at the local level, in combination with the pressure to implement a 'successful' project, led to the mobilization of a new hybrid collective centered around an entrepreneur from Yogyakarta, who in turn added his own machines and operators to the biofuel processing machines provided by the government. While this addition succeeded in increasing the productivity of the biofuel processing unit, the demand for the Calophyllum from the newly included non-energy buyers remained low at about 75 liters per month, posing a significant challenge to the designed 100 liters per day production capacity of the ESV. Was this a case of friction by non-energy buyers or simply the result of a miscalculation by the entrepreneur's hybrid collective? In any case, attempts were made to address the issue of low demand by organizing the material spectacle of a high-profile Road Test.

4.5.3 Friction #3: Resistance in Representing Things

Calophyllum trees were first planted by the Purworejo forestry department in 1950 along the coastal line of the district, covering an area of 10.6 hectares. By breaking sea winds, these trees enabled local farmers to plant corn, chili, papaya and wet paddy at around 100 meters from the sea, which was initially impossible due to the high wind speed. This program continued until 1980 by when Calophyllum trees had spread to an area of more than 135 hectares (Bustomi et al., 2010).

Under the ESV program to develop biofuels between 2008 and 2012, the humans constituting Purworejo's local Calophyllum collective were primarily local farmers and the forestry agencies (Perhutani and Forestry Research and Development Agency or FORDA). In 2012, when *Sinar Bhineka* (the Yogyakarta entrepreneur's firm) joined this collective, it started monitoring Calophyllum pickers by hiring a supervisor whose function was to ensure that the pickers sell Calophyllum fruits only to the ESV cooperative (even if the price offered was low). The entrepreneur deployed the argument that since the fruits came from the government's forest, these fruits should be used exclusively to support the government's ESV program. This argument was resisted by Perhutani (the state-owned forestry corporation), which was supporting Calophyllum for biofuels as part of its corporate social responsibility program. According to Perhutani, the pickers should be allowed to sell the fruits to any buyer who offers them a high price, and enables them to make a good profit. Villagers expressed a similar expectation and thus intensified the friction between Perhutani and the entrepreneur.

As scientists became involved in testing Calophyllum, they turned the materiality of Calophyllum into numerical measures of its density, viscosity, fogging point, acid number, phosphorus content and others. The scientists' practice (their method and the materials used in their laboratories) created Calophyllum numbers that were translated out of the laboratories and into policy documents. This translation obviously did not carry over the scientists' entire hybrid collective (including their controlled laboratory conditions and testing materials) into government offices. Yet through the travelling numbers, as they became embedded in public policies and business models, and as the policies and models were implemented, the scientists' calculations were confronted with other entities in the field. These entities such as trees, farmers and fruits resisted or were not able to confirm the validity (or accuracy) of the numbers presented by the scientists' calculation. In other words, the scientists' representations of the Calophyllum trees and the farmers' labour, as producers of harvestable fruits 3 times a year, were effectively resisted: harvests were never done more than twice a year and even that was heavily dependent on the length of the rainy season. As one operator of a local biofuel processing unit explained, "in rainy season, Calophyllum fruit does not ripen, falling from the tree without becoming ripe. Only in the dry season do we get good Calophyllum fruits. Additionally, to get good oil, we still have to filter the dry season fruit by putting it in water, picking the ones that sink."

The scientists' calculations on the oil content of Calophyllum, as discussed in the previous section, which underlie the national government's ESV project, were performed by isolating causality between the Calophyllum fruit and the oil yielded in a controlled environment. Obviously the calculations confront a differently (and perhaps less effectively) controlled environment during actual projects in the field. In this sense then, the reality of actual projects is underdetermined by the scientists' calculations (or any other calculations for that matter which may undergird policies and business models). Thus, it is not that the scientists' calculations were wrong, but rather they were a valid product of their controlled (laboratory) environment, or their hybrid collective, within the bounds of which reality could be effectively tamed and accurately represented (cf. Stengers 2010). Their truth in this sense was true only in its own hybrid collective.

Inside actual projects, during implementation in local hybrid collectives, one may argue that other entities such as rains and fruits play more diverse roles (as demonstrated by the explanation of the biofuel processing unit operator above) than they are permitted inside the scientists' laboratory. Even though this qualitative diversity of entities' actions is subject to

attempted control or management by the projects' administrators, the entities often manage to resist this control in practice and produce what we are documenting here as frictions.

4.5.4 Friction #4: The Weight Change Problem

The manufacturing firm Trakon's entry into Purworejo's ESV project in 2007-8 afforded the emergence of a hybrid collective involving Trakon and the local farmer-pickers of Calophyllum. We narrate the frictions in this episode by following Lasiyah, a farmer-picker. In joining this new collective, Lasiyah cycled around 10 kilometers every day during harvest time of Calophyllum from her house to the forest to pick fruits. She picked the fruits that had fallen to the ground between tall grass, bushes and trees. During the harvest season, she could collect up to 100 kilograms per day (in seven hours), leading to a daily income of about 100000 IDR. This activity of picking Calophyllum and receiving sporadic income from selling it lasted for two years until the end of 2009 when Trakon decided to end its operations in Purworejo and the Ministry of Forestry handed the biofuel processing unit to *Wana Lestari* (the local village cooperative). Until Trakon's departure, which may be viewed as the first friction encountered by the course of action for Lasiyah's Calophyllum activities, she had sold 15 tons of Calophyllum fruits for 1000 to 1200 IDR per kilogram.

A reconfigured collective for Lasiyah's work emerged in early 2010 when the Yogyakarta entrepreneur started to buy Calophyllum fruits from her. When not collecting Calophyllum, Lasiyah often worked as a labourer on others' farms. Her primary job was working in the paddy fields where she led a group of seven labourers, most of whom were male. By working in the paddy field, she would receive 90000 IDR per day. Even though collecting Calophyllum fruit was more profitable than working in the paddy field, she considered working in paddy field easier since it was finished in the field and she did not need to bring work home. For Calophyllum, she had to collect the fruits, put them in sacks, bring them home and wait until the fruits were picked up by the buyer. Fortunately, between 2010 and 2011, the entrepreneur gave her money in advance for the Calophyllum and agreed to take the fruits even when they were wet. The main reason why she became involved in picking Calophyllum was the gap in the paddy cultivation cycle during which she had to look for alternative jobs.

In early 2012, the entrepreneur reduced his involvement in the ESV cooperative by handing the responsibility of buying Calophyllum fruit to Agus, the operator of the local biofuel processing unit. This change produced another friction for Lasiyah because Agus had to reduce the price for Calophyllum fruit from 1000 IDR to 700 IDR. He also decided to buy fruit that was dry rather than wet. In March 2012, Lasiyah told us that picking and collecting Calophyllum was no longer attractive for her and her colleagues. In her most recent transaction, she had lost

800000 IDR due to weight loss of Calophyllum fruits during post-harvest storage stage. In addition to collecting fruit herself, she had also bought some wet Calophyllum fruit from her neighbors for 500 IDR per kilogram and sold it as dry fruit for 700 IDR. She had expected to make a small profit from her work of storing and drying the wet fruit, but the dried fruit weighed only about half of its wet counterpart. In addition, the issue of weight became a source of conflict between her and Agus because they were using different weighing scales. Lasiyah's loss was made worse when Agus asked her to bring the fruits to the site of the biofuel processing unit rather than picking up the fruits from her home. These re-arrangements made her profit much smaller than the one she used to get from Trakon and from the entrepreneur, and forced her to re-evaluate her involvement in the ESV project.

Another local picker, Barman (an adult male) had also stopped collecting Calophyllum after Agus took over the Calophyllum ESV management. In fact, during the last fieldwork trip in March 2012, we observed that most people who still picked Calophyllum were either women or children. According to Lasiyah, this composition was a result of a division of labor between women and men, according to which women mostly dealt with small or unused land and men mostly worked in paddy fields. Lasiyah was an exception to this since she had lost her husband.
In this episode, frictions emerged due to the departure of human actors, changes in 'weight' of Calophyllum fruits in storage as the fruits were drying, and the use of different weighing scales. The pickers and the buyers/operators of the biofuel processing unit had not predicted the extent of weight loss during storage and had not standardized the weighing scales. Thus the relationships between pickers and buyers were mediated through nonhumans such as the weighing scale and through methods for deciding the right time and the right product (wet or dried Calophyllum fruit) for the transaction.

4.6 Concluding Remarks

The aim of this article was to identify useful ways to account for how nonhuman (material) entities actively shape development practices. In order to realize this goal, we proposed to revise the notion of agency by viewing it not as the capacity of a human being to change a state of affairs, but rather as an effect of actors' relations with each other. Thus, the agency of a human being or of a nonhuman is distributed across a hybrid collective. A hybrid collective is (re)configured through translation, a process through which any new (calculative) entity such as a policy/model is adjusted into an existing collective, trans-forming existing practices. Adapting the concept of friction from Tsing (2005) we argued, and attempted to demonstrate using four

empirical episodes of transforming hybrid collectives, that translation processes encounter resistances posed by human and nonhuman entities.

From the episodes of friction, we can identify four ways in which nonhuman entities resist, always afforded by their relations with significant others, and (re)shape development practices. Our listing of the four ways is not exhaustive and other ways could definitely be identified through further research on the role of nonhumans in development practices. Additionally, while we do not discriminate between nonhumans' distinctive agency (resistance/friction) according to their general classification as plants, animals, models, tools or technologies (preferring not to classify diverse nonhuman agency according to these prior categories), such an examination may be a productive avenue for future research.

A. *Nonhumans resist representations (e.g. calculations embedded in policies and models).* In the second episode narrated above, Calophyllum fruits and biofuel processing machines (by yielding less than a third of the predicted oil output) resisted the calculations embedded inside the national government's policy and the Energy Self-sufficient Village (ESV) business model. Through this resistance, they forced a one-year hiatus in oil production in Purworejo and eventually led to new local calculations by an emerging constellation of actors involving an entrepreneur (and his workers and machines) and forestry agencies, which gave rise to new local business models for the ESV.

B. *Nonhumans redirect action.* Nonhumans did not only resist their representation in official calculations and categories, they also redirected action by affording a hiatus in oil production and by forcing new local calculations. Similarly, in the first episode about the friction between two Indonesian Ministries, materiality of vegetation shaping their categorization as plants or trees played a role in redirecting development practices. Thus, this entanglement between material entities, their classification (that may be treated as a nonhuman entity in itself), and rules for division of labor between Indonesian ministries led to a redirection of action by the Ministry of Forestry (toward a focus on Calophyllum inophyllum instead of Jatropha curcas).

C. *Nonhumans change (as they travel) over time and space.* In the final episode, Calophyllum fruits' material texture reacted to the passage of time and to movement between two different weighing scales, creating a disagreement between the pickers and the Calophyllum buyers. Some pickers stopped engaging in Calophyllum collection practices as a result of this disagreement. This illustration highlights the significance of changes in nonhumans as they move in time and/or space for re-directing practices. This is consistent with our conceptual framework on translation, according to which the arrival of a new or changed entity reconfigures existing collectives and transforms the practices enacted by these collectives.

D. *Nonhumans mediate competition for resources.* In episode 1, we documented how the materiality of biodiesel feedstock as a short bush or tall tree influenced the flow of resources to different Ministries, mediating competition between them for the national government's biofuel development resources. The Ministry of Forestry had to abandon its Jatropha curcas activities, which were taken over by the Ministry of Agriculture. The latter Ministry ended up gaining more resources than the former, for biodiesel development from various other national ministries. Thus Jatropha curcas, due to its very materiality as a plant rather than a tree, no doubt afforded by a range of other actors including designers and enactors of botanical classification systems, mediated the competition between the two Ministries.

Returning to the caveat discussed in episodes 2 and 3, we must ask if the cases of friction based on resistance afforded by nonhumans (and humans) are simply consequences of prior miscalculation by actors who misrepresented nonhumans and devised badly planned courses of actions (for others and themselves). Taking the issue of categorization, for instance, by treating a short bush or plantation crop to fall under its jurisdiction, did the Ministry of Forestry not simply make a mistake? Obviously, in hindsight, it is easy to conclude that the Ministry backed the wrong horse and, in this sense, it made a mistake (even some Ministry officials might accept this), but this would be an oversimplification even if the responsibility of such a 'mistake' is distributed among all the actors that constituted the Ministry's policy. More importantly, however, perhaps the 'mistake' was not based on miscalculations by scientists, policymakers or project administrators. Instead, the calculations may have been *true*, not in all situations and under all conditions, but only in the hybrid collectives that constructed them. These hybrid collectives may be found in the form of social and material relations that constitute scientific facts, economists' calculations, policymakers' proposals, entrepreneurs' strategies or farmers' plans. And each collective may be a maker of its own distinctive and partial truth that may no longer be true outside the collective in question, even when universal validity of the truth is proclaimed. In fact, due to this bounded validity, the truth's entry into other collectives, and the resultant course(s) of action, may be resisted by entities populating the other collectives. And this resistance may continue until the quest for applying the truth is abandoned in the other collectives, or the truth is adjusted (as are the collectives themselves) for achieving new validity.

Overall, the four episodes of friction demonstrate that *nonhumans make and unmake domination in practice*. The various frictions also demonstrate how the Calophyllum Energy Self-Sufficient Village (ESV) project of the national government failed to meet its stated objective. Many different human and nonhuman actors (machines, chemicals, oil-bearing fruits, weighing scales etc.) in the field, introduced by the central government to support its biofuel policy and

business model, failed to act as pliant objects that act in collaboration with the government's plans and expectations. Instead the objects resisted, their resistance always afforded by relations with other nonhumans and humans, working to unmake the government's domination and control over local actors. Yet the same nonhumans (alongside new ones ushered in from Yogyakarta) later enrolled by the entrepreneur (and his company), and therefore afforded by a different set of relations than in the government's hybrid collective, facilitated his temporary domination of Purworejo district's ESV.

In drawing attention to this relationally-situated activity of nonhumans, in addition to calling for future research into the effects of relations between humans and nonhumans, we hope to draw the attention to the politics of spokespersons who (can) speak the truth on behalf of nonhumans. We aim to raise the question: how do we proliferate these voices beyond the monopoly held by scientists, engineers and other experts (as the 'traditional' spokespersons of things: cf. Sayes 2014). Broadening the ambit of reliable spokespersons to include actors such as small farmers, entrepreneurs, NGO representatives and other ordinary people may be crucial for democratizing and pluralizing development discourses and practices. And this democratic pluralism of 'expert' yet ordinary voices may be essential for articulating and enacting genuinely empowering transformations.

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5. Following Jatropha from Bandung to Sumbawa: Entanglement between University and Industry in Practice [45]

Abstract

This paper contributes to understanding innovation in an emerging economy by building on the STS concept of entanglement and collaboration. Specifically, it develops an analytical framework to capture the duality of innovation actors in creating novelties and in maintaining regularities of the existing economic and political contexts. Entanglement is characterized by the emergence of new associations, which allow the actors to innovate, while collaboration is characterized by the presence of new activities to maintain the existing economic and political contexts. The paper demonstrates that the transformation of Jatropha-based fuel from invention to commercial transaction was facilitated by a series of incremental collaborations, which lasted temporally depending on the context. The paper suggests that the local institutional context plays a crucial role in allowing actors to take autonomous actions to pursue biofuel innovation. However, when their strategy encountered an unfavorable socio-economic environment due to political change at the national level, their ability to accomplish their economic goals through new innovation began to decline.

Keywords

Entanglement; innovation; Jatropha; university

5.1 Introduction

In June 2006, the Minister of Research and Technology Kusmayanto Kadiman, met President Susilo Bambang Yudhoyono to report the progress of Indonesian biofuel development. The Minister reported the success of the state-owned oil company Pertamina in selling biodiesel in selected fuel stations, and the positive result in carrying out experiments to add 10% of bio-oil in fuel consumption. Kadiman optimistically predicted that the biofuel business would be able to provide 3.6 million farm jobs and to take 2,280 skilled workers from vocational schools and

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universities.[46]At that time, President Yudhoyono faced a big problem due to his unpopular decision to reduce the national oil price subsidies. Mass demonstrations appeared in large cities such as Jakarta, Surabaya, Bandung and Palu, which involved burning tires and effigies and long march to government offices (Tyson, 2005). Yudhoyono justified his decision to remove a large proportion of oil subsidies as a bitter, yet necessary pill to save the state budget, especially after Indonesia had became a net oil importer country since 2004. To deal with the energy crisis, he called for new approaches of energy policy that could directly contribute to providing jobs and raising incomes of the poor.

After learning about biofuel potential in creating jobs, Yudhoyono decided to hold a special cabinet meeting in Losari, Magelang, Central Java to draw commitment of relevant stakeholders to developing biofuel (Dillon et al. 2008). Before his ministers and representatives of the stakeholders, he proposed a new policy, which he refers to as "Post-crisis New Deal." It has a three-fold objective: to boost economic growth, to create jobs, and to alleviate poverty, all achieved through one integrated program. He described the "New Deal" as a host of short-term programs that would have direct impact on poverty and on rural-urban inequality. Furthermore, Yudhoyono claimed that the new program was not contradictory to the macro economy and fiscal policy. Given that the new program came directly from the country's most powerful man, all the stakeholders agreed to support the biofuel development as an important energy source.

To successfully implement the biofuel program, Yudhoyono assigned several cabinet members along with provincial governors to get directly involved in the top-down program. Concomitantly, district governments were encouraged to take measures that would motivate farmers to start cultivating biofuel crops. Amir et al. (2008) explain that the international oil price hikes and Yudhoyono's unpopular decision to increase the national oil prices in 2005 played a role in pushing biofuel researches as well as mobilizing institutional resources to support biofuel development especially in rural areas. Interestingly, this was not the case when the international oil prices soared in the early 1980s; no interest of the government and other stakeholders was shown in developing biofuel. The limited effect of the international oil price in 1980s hikes was due to the fact that Indonesia was then an oil-rich country. This suggests that transformation in the energy sector was not only shaped by the politics of oil subsidy, but also by the volatility of international oil prices.

To understand how the political decision, international oil price dynamics, oil supplies, and the government plans pushed biofuel innovation in Indonesia, this paper investigates the biofuel

[46]The Ministry of Research and Technology presented Biofuel. Available online: http://www.presidenri.go.id/index.php/fokus/2006/06/14/658.html. Accessed on April 2, 2014.

innovation, specifically focusing on the use of Jatropha as the main material to examine its first commercial transaction by the users (Akrich et al., 2002). It is argued that the macro context of this innovation, namely international oil price, national politics, and availability of material resources, are not sufficient to mobilize biofuel innovation. To explain this problem, the paper applies the notion of "entanglement", which refers to "associations that last longer than the interactions that formed them" (Callon & Latour, 1981:283; Rip, 2010). This means that the entanglement of biofuel actors has to be established for the biofuel innovation to succeed. In using the concept of entanglement, I translate the term 'last longer' through the notions of "intermediary" and "mediator." Latour (2005) describes intermediary as associations that are formed to maintain existing networks, while mediator as activities that destabilize the existing networks and allow actors to have new routines. Entanglement is characterized by the presence of mediators (e.g. increases of national oil price that led to political instability) where new routines, which in this paper refer to Jatropha-related activities, last longer than interactions that formed them. Opposite from entanglement is collaboration, defined as activities of working with another actor/institution that do not last longer than interactions that formed them. By focusing on the actors' entanglement, I will show that rather than treating the actors' ability to produce knowledge, regulations, and financial profits as part of their identity, these abilities are developed through entanglement between heterogeneous actors.

5.2 Dynamics of Innovation

Leydesdorff and Zawdie (2010) describe the dynamics of an innovation system as being shaped by a multitude of interactions of economic demand/market mechanism, politics of resources, and mechanisms for generating new knowledge. Interactions between these elements give rise to new properties that are different from properties of the elements that built them, and thus disallowing *ex ante* coordination since the emergent properties are not yet been discovered at the beginning. Etzkowitz (2011) suggests that interactions between these elements become more difficult to be separated since the activities are continuum rather than dichotomous. He demonstrates the presence of hybridity where scientists become entrepreneur, academia becomes quasi-firms, and the economy functions as an epistemological system.

The hybridization of actors or institutions also appears in the shift in knowledge production from 'Mode 1', characterized by scientific discovery, single-discipline and largely academic to 'Mode 2', characterized by interactions, trans-discipline and application-oriented knowledge (Gibson et al., 1994). While 'Mode 1' may also have practical applications, its application is always separated from the actual time and space where the knowledge is produced

(Hessels & van Lente, 2008). Mode 2, on the other hand, produces knowledge in the context of application. It is produced in a specific environment, through particular methodologies and to address peculiar problem (Gibson et al., 1994). In order to meet its end, Mode 2 is characteristically trans-disciplinary where multiple theoretical perspectives and different methodologies are used to solve problems. The conceptualization of Mode 2 suggests that knowledge, rather than being transferred from the producer to the consumer after being produced, is produced through interactions between different actors or co-producers of knowledge.

In the Indonesian context, the study of innovation is most frequently conducted within institutional perspectives where actors are seen to have definite roles based on their formal positions (e.g. researchers on R&D; policy makers in government agencies; entrepreneurs). For instance Lakitan (2013) argues that the national innovation system in Indonesia faced several key issues, including low adoption of the local technology, low demand of technology by domestic users, limited interactions between users and developers, and an Ivory Tower syndrome among researchers in universities and public R&D. In building the argument, Lakitan combines quantitative and qualitative data where he compares Indonesia's funding allocation for R&D from domestic industries that made only 14.2 per cent in 2012, as compared to the U.S. that reached 70 per cent in 2006. To stimulate entanglement between university and industry, Lakitan observes that the government had issued Regulation 35 Year 2007 on tax incentives for business enterprises that support R&D activities. However, due to the absence of technical guidance from the Ministry of Finance, this tax incentive has never been implemented (Lakitan, 2013). This institutional observation highlights differences between university and industry due to their structural identities, despite they share innovation activities.

This institutional perspective is applied by Moeliodihardjo et al. (2012) to investigate interactions between actors from different institutions. It shows that apart from government-led programs, which aimed at increasing interactions between university and industry, individual professors build active relationships with the industry through consultancy. Despite acknowledging this connection, Moeliodihardjo et al. (2012) describe interactions between universities and the industry as problematic due to a lack of mutual understanding and an absence of effective policies to support the university-industry linkage. It is this contradiction in the lack of linkages at the institutional level while collaborations at the individual level are growing that calls for a suitable approach to capture the duality of actors and their socio-economic contexts.

5.3 Methodology

To capture the duality of actors and institutions in innovation practices, a Grounded Theory was applied to build the research strategy presented in this paper. Graebner (2004) and Eisenhardt and Graebner (2007) suggest that the Grounded Theory is suitable for research with a lack of prior studies regarding the specific issue in question. The Grounded Theory focuses on the interpretative analysis on what happened in the real-world setting without ignoring causal relations between actors (Suddaby, 2006). It aims at generating information about the social phenomena under examination, and thus is different from phenomenology that aims at producing stories from an individual subjective. With this feature, this methodology allowed me to investigate entanglement of multiple actors in the biofuel development in Indonesia. In my fieldwork, I was guided by the concepts and indicators as seen in Table 5.1.I collected data and information from a variety of sources as follows: a) 25 in-depth interviews; b) a series of fieldwork in Bandung and Sumbawa between June 2007 and January 2011; c) intensive interactions with the engineers at Bandung Institute of Technology (ITB); and e) policy archives and technical documents. In Sumbawa, a mobile ethnography was conducted in which a businessman and I took a road trip across Sumbawa Island (around 300 kilometers) to meet farmers and biofuel buyers. The term mobile ethnography refers to participation of the informant in deciding which places to investigate and thus, creating a fieldwork space that is shaped by my interest to understand Jatropha activities in Sumbawa and the informant's network and views toward his network (Sheller & Urry, 2006; Urry, 2007). These evidences were gathered to enrich the existing literature on knowledge production in Indonesia, which is predominantly institutional analysis while the present study emphasizes more on relational analysis.

Table 5.1 Concept, functions and indicator to analysis entanglement in innovation (adopted from Verhees et al., 2013)

Conceptual Lens	Description	Looking for evidence of
Entanglement	Emergent effect created by interactions between heterogeneous actors that make it up	Interactions between heterogeneous actors that are needed to transform biofuel invention to innovation
Mediator	Activities that destabilize the existing networks and allow actors to have new routines	New activities that allow actors to have biofuel-related routines
Collaboration	Activities of working with another actor/institution	Interactions between heterogeneous actors that are needed to maintain the existing routines
Intermediary	Activities that maintain existing networks	New activities that last temporally according to the existing contexts

5.4 Biofuel Innovation in Action

Since the late 1970s, concerns about the decline of oil supply had prompted government research agencies in Indonesia (Yuliar et al., 2006). In response to this concern, the Suharto government issued the General Energy Policy in 1981 aiming at energy intensification, diversification, and conservation. In 1983, the Center for Starch Technology in Lampung started a research project on cassava-based bio-ethanol. This research was collaboration between the Center and local sellers of cassava. The sellers were then looking for alternative markets due to over-production. The collaboration, however, only lasted for a short time. Most of the documentations of the research were unfortunately missing (Timnas, 2007). In the 1990s, initiatives to revive biofuel research were taken by public research agencies and universities such as Agency for Oil and Gas, Agency for the Assessment and Application of Technology, Center of Palm Oil Research, Bandung Institute of Technology and *Sepuluh November* Institute of Technology. From 1994 to 1997, the Agency for Oil and Gas, for instance, collaborated with Pertamina to conduct a market experiment, which resulted in the production of palm oil-based biodiesel (Timnas, 2007). However, due to the uncompetitive price of bio-diesel to conventional diesel, the collaboration came to an end.

Despite the failure of the afore mentioned efforts to transform biofuel into an important energy source, it is worth noting that the whole episode of biofuel innovation in the 1990sdemonstratesa Mode 2 knowledge production. This finding challenges previous studies that claim low adoption of national technology, low collaboration and tendency to ignore actual problem as the obstacles in establishing effective innovation system in Indonesia (Lakitan, 2013). By moving beyond the university and industry linkages, the story above implies that the success of an innovation system was influenced not only by individual or institutional interest, but also by the presence (or the lack of it) of market protection. The case of biofuel innovation by researchers at Bandung Institute of Technology tells a different story. It is a successful undertaking to transform biofuel innovation into biofuel market due to entanglement as argued in this paper. How this case results in different outcomes will be elaborated in the following section.

5.4.1 The ITB Biofuel Engineers

Originally founded by the Dutch colonial government in 1920, Bandung Institute of Technology (ITB) was opened by the Indonesian government in 1959 with a mission to carry out *Tridharma*, consisting of teaching, research, and community service. After years of being part of the state

bureaucratic structure, in 1999 ITB was selected along with three other state-funded universities to become "autonomous university." This status afforded ITB to have an independent body that is separated from the government bureaucracy (Yuliar & Syamwil, 2008). However, it also gave ITB pressures to find funding supports from non-governmental sources. Two major sources of revenues were established, namely student tuition fees and campus-based entrepreneurial activities (Beerkens, 2009). ITB researchers had mixed responses towards this change of status. Those who disagreed argued that ITB is an education institution, not appropriate for profit-making business, which is deemed as against the norms. Those who were in favor believed that the shift towards business-oriented institution allowed them to manage its own sources of financial gains without being controlled by the government (Yuliar & Syamwil, 2008).

ITB's Institute of Research and Community Service (IRCS) has played an active role in fostering university-industry linkages. According to IRCS, collaborations between ITB and other parties such as industry, local governments, and non-governmental organizations (NGOs), are either assigned by IRCS or initiated by individual researchers.[47] These intensive collaborations allow ITB faculty members to build strategic relationships with industries and NGOs. IRCS provides legal and administrative supports to ITB researchers who wish to collaborate with external partners. For these services, IRCS received a fee of 17% of the amount of contract signed under IRCS. This considerably large amount of fees, however, created disillusionment among the researchers. In response, as explained by an officer of ICRS, IRCS instituted a standardized procedure to ensure transparency in the expense of revenues for researchers' interest. Such an agreement was implemented, for instance, in the memorandum of understanding between ITB and a state-owned Rajawali Nusantara Indonesia (RNI) to develop bio-refinery facility to speed up Jatropha production.

The Center for Research on Energy is another research institute at ITB that has actively searched for non-government grants since its establishment in 1981. The Center had received funding for biofuel research and development from international agencies such as United Nations Environment Program, the U.S. Agency for International Development, the World Bank, and Tata Energy Research Institute (Fatimah, 2008). There are two key researchers of this center who have played important roles in the development of biofuel in Indonesia. One is Dr. Pratikto, the other is Dr. Dadang. Compared to Dadang who was active in the politics of biofuel, Pratikto was more interested in technical applications of biofuel research. A faculty member at Chemical Engineering Department, Pratikno had built a small-scale biodiesel processing unit in Manado. With support from Department of Energy and Mineral Resources, he had installed

[47]Interview with Ibu Ari, August 23rd, 2007. All the names in this paper are pseudonym.

another processing unit in Gorontalo. Pratikto explained that the university allowed him to work with any research groups and that the Biodiesel Research Group had won a research grant to continue its biofuel research[48] working with *Rekayasa Industri*, a state-owned company that has a close relation with ITB.

While Pratikto concentrated more on the technical aspects of biofuel innovation, it was Dadang who was able to mobilize available resources to achieve a larger goal in biofuel innovation. Dadang finished his PhD degree at the *Technische Hogeschool* Delft, the Netherlands in 1985 by studying the use of metal oxide on alumina acceptors to remove H_2S from the product gas of coal gasifiers. He became interested in biofuel through his involvement in the Center for Research on Energy. In 2001, he identified different energy crops such as Jarak pagar (*Jatropha curcas*), *Kemiri* (*Aleuritesmoluccana*) and *Kemiri sunan* (*Aleuritestrisperma*) as potential sources for biofuel production in Indonesia. As a way to enroll other actors to support his belief on the critical role of biofuel, Dadang formed Indonesian Biodiesel Forum, an initiative he organized with other researchers from universities and public research institutions. Due to his strong influence and leadership, he was elected as the founding chair. Apart from chairing the Forum, Dadang was also a member of the Technical Commission for Renewable Energy at the National Research Council of Indonesia, and since 2013, a member of the Indonesian Academy of Sciences. As he revealed during an interview in 2007, Dadang's interest in Jatropha was prompted by the advantage of this crop especially for farmers in rural areas. "Jatropha is perfect because its waste can be used for making biogas that could benefit farmers." He added by highlighting the fact that biofuel could easily be transported. In carrying out his research, he took different strategies. The first one was to collaborate with researchers from different institutions, using his connections in the Indonesian Biodiesel Forum. This made his work recognized by policy makers in Jakarta. The second was to submit a number of proposals to the government-industry grant scheme called the Research between University and Industry. The third one was to offer the results of his ITB-based laboratory to small-medium enterprises (SMEs). The latter allowed the SMEs to get technological supports from his research group. Worth to note is his emphasis on the need to rely on informal relations. "In Indonesia, formal relations only worked for making the biofuel policy. However, it did not really work because it tried to accommodate everyone's interests and yet, lacked clear guidance as to how the policy could be implemented."

Dadang pointed to politics as the main hindrance. "Many politicians tried to exploit biofuel development in Indonesia for their own interest, while biofuel policy has not been properly articulated. Consequently, biofuel innovation faded before it has achieved a critical mass

[48]Interview with Dr. Tomo, September 21st, 2007.

to grow. The situation would have been different if we have smart politicians. Few people blamed us for not being in the Parliament. They said the Parliament is the one who decided (on the future of biofuel) while they know nothing about it."[49] Furthermore, he believed that the knowledge that had been brought back to Indonesia by most scholars was imported knowledge. "Most Indonesian people acquired foreign knowledge but no local knowledge. Our people take western countries as the benchmark. The fact is that it is unlikely for us to follow them since our conditions are different compared to them."

In 2001, Dadang, Pratikto, and Imam from the Mechanical Engineering Department formed a new research group called Biodiesel Research Group. In 2003, this group started producing Jatropha-based fuel relying on raw materials supply from Sumbawa. Jatropha-based fuel instantly became a growing trend among members of the Indonesian Biodiesel Forum, which was chaired by Dadang. The forum aimed at promoting biodiesel production and utilization in Indonesia as part the commitment of the forum members to good citizenry by contributing to the sustainability of domestic fuel supply as well as to the economic well being of the Indonesian people (Soerawidjaja, 2003). Through promoting biodiesel production, the forum expected businessmen, national leaders, and civil society elements to have common understandings about the crucial and strategic role of biodiesel. This would motivate them to participate in biodiesel production, thus creating large-size markets for biodiesel. In addition, the trend would generate activities to explore and to exploit various energy sources, and eventually drive technological development for this energy source. To achieve the main goal of the forum, between 2002 and 2003 researchers who affiliated with the Forum decided to concentrate on studying Jatropha as a potential energy source. The results of efforts by multiple actors involved in Jatropha-based biofuel innovation were presented in the meeting on 28 August 2002. During the national meeting, one member of the forum who is a researcher from the National Atomic Energy Agency (BATAN) demonstrated a successful genetic mutation of Jatropha crop using nuclear radiation. Another researcher from the Ministry of Forestry exhibited the success of his department in cultivating Jatropha curcas by producing 20 seeds per tree with weight one to one-half kilogram.

Needless to say, the Forum succeeded to unify all Jatropha researchers in a concerted effort to draw attention from lawmakers. This was materialized in one national meeting on 6 February 2003 where Dadang gave a keynote presentation entitled 'Why biodiesel have to become part of the Indonesian liquid fuel mix'. His presentation highlighted how Indonesia had become a net oil importer, and why it is extremely important to develop biofuel to replace fossil

[49]Interview with Dr. Dadang, May 11th, 2007.

fuel. In response to the presentation, a few parliament members expressed their firm support to biofuel production although with a note: "Demonstration plot and market research should be completed before one could develop biofuel in large scale." Dadang responded that one of the main challenges in biofuel development in Indonesia was a lack of coordination between the Ministry of Agriculture and the Ministry of Energy and Mineral Resources. He continued by saying that for a short period of time, it is possible to focus on palm oil-based fuel due to its availability but for a longer term, each region has to develop its own energy source.[50]

5.4.2 Biodiesel Small-medium Enterprise in Sumbawa

One of the small-medium companies resulting from Dadang's research group was *Industri Tanaman Energi* (ITE). The company was established by Baim, a Sumbawa born-man who studied in Bandung and became involved with Dadang's project through his interest in biofuel. In 2002, Baim started to supply Dadang's research group with Jatropha seeds from Sumbawa. This collaboration afforded Baim not only a market for his local crops, but also technical know-how from ITB and financial capital from state-owned telecom company, Indosat, which he used to setup biodiesel processing facilities in 2007 in his hometown in Sumbawa. "We have a contract with Indosat in which we have agreed to supply them with 33,000 liter of biodiesel. In return, they would pay us in advance," said Baim. Indosat used biofuel to backup generators of their base transmitter system in Sumbawa and Lombok. In the mid 2009, ITE succeeded in producing its first Jatropha fuel with a production capacity of 1,000 liter per week. "We have a plan to increase the production capacity to 2,000 liter per day after a Japanese company approached us to be our international partner," added Baim.

To ensure a continuity of Jatropha supply, ITE founded a cooperative of local farmers called SETIA in 2009. The cooperative had over 200 members in 25 farmers groups (Gaul, 2012) within an area of 1,200 hectares. Through SETIA, ITE purchased Jatropha seeds from these farmers. In the future, Baim hoped the farmers would develop capacity to convert seeds into oil to increase their income. In running his company, Baim's family also participated. His parents were responsible for operating the processing unit, while Syafri, Baim's little brother was responsible for maintaining Jatropha supply from the farmers. In areas close to Alas sub-district, Baim's father coordinated the farmers to cultivate Jatropha due to his leading position among the local Bungin tribe.

[50]Minutes of meeting of the meeting between the Indonesian Biodiesel Forum and the Parliament, February 6th, 2003.

Sumbawa is an agrarian island in West Nusa Tenggara Province with a population density of 85 persons per square kilometer (Gaul, 2012). The Directorate General of Electricity and Energy Development notes that in 1997 the province had biomass energy potential of about 5.4 GWh mainly in the form of rice husk (65 per cent), wood (21 per cent) and corn and cassava waste (13 per cent) (Purwanto et al., 2006). Gaul (2012) observes that Sumbawa villagers had used rice husks for litter and fodder, or as fuel to burn bricks and that many villagers who work as farmers saw Jatropha as a cash crop. The Regional Secretariat (*Sekda*) of West Nusa Tenggara Province noted that:

> "Jatropha development in the province was stimulated by two historic events: the governor's visit to Japan from wherehe brought back a pressing machine to produce Jatropha oil, and secondly, a Jatropha road show (organized by ITB and National Geographic Indonesia) from Bandung to West Nusa Tenggara and East Nusa Tenggara (in 2006). Our land and energy situation create the opportunity for Jatropha development […]. Currently, we use diesel as fuel to generate electricity whose supply often arrives late for many reasons. Therefore, Jatropha is potential for solving energy scarcity in our province."[51]

The local government followed up these events by distributing Jatropha seeds to local farmers, an action that went hand-in-hand with Jakarta's Energy Self-sufficient Village program. The latter aimed at creating energy self-sufficiency in rural villages across Indonesia. It started with a number of selected villages that were given biofuel processing unit, electric generator, and financial supports for a three-month operation. These activities inevitably triggered Jatropha hype in Sumbawa and other areas in Indonesia (Afiff, 2014). Despite these activities, the Energy Self-sufficient Village program failed to continue due to a lack of protection on this emergent market (Amir et al., 2008; Fatimah, 2015). One selected village that I visited in Poto Tanu, Sumbawa remains in a poor condition. The biofuel facility almost collapsed and the processing machines had corroded and spoiled.

Damar, the son-in-law of the land owner explained that his father-in-law received the biofuel processing machines from the local government as part of the Energy Self-sufficient Village project. In addition to technological and financial supports, the government also provided training on how to operate the machines. Despite these supports, the machines were only used once due to a lack of cash-flow for the program. Thus, his involvement with Jatropha was only limited to selling fruits to C&G Biotech.

> "Our involvement with the national program was mediated by the Industry and Trade Service of the Province of West Nusa Tenggara. They surveyed what we needed to run the program. In the design, it is stated that we will get the funding needed to produce biofuel, but in reality, we never received it. Therefore, we left

[51]Minutes of meeting of Provincial Workshop in Mataram,Lombok, NTB, 29 October 2007.

> the machines abandoned in the storeroom. Sumbawa has a great potential for Jatropha development. Unfortunately, the district government was not very serious in supporting Jatropha initiatives that came from the farmers."[52]

When I visited Sumbawa in January 2011, most of SETIA members had substantially reduced, or even stopped, planting Jatropha. Syamsul, one of the famers who I met in the field told me that he only grew Jatropha curcas in area of two hectares since 2006 when the local agriculture office distributed Jatropha seeds freely to Sumbawa farmers. He thought that by doing monoculture farming he would be able to make more profits. For a half of year, Syamsul could only make IDR 1,500 (approximately US$1.20) per kilogram of Jatropha seeds sold to ITE. In the second year, he received a better offer from C&G Biotech, a South Korean energy company that bought his Jatropha fruits for IDR 2,000 per kilogram. However, due to a restructuration in the C&G Biotech, the company decided not to continue developing Jatropha-based biofuel. This led Syamsul to cut down his Jatropha trees.

In the car during my visit to Daeng, another SETIA farmer, Baim's father defended that he never suggested the farmers to do monoculture farming, nor he promised high profits. What he asked from the farmers was to do a collective experiment where they might make profit from the new crops. However, due to a strong motivation to maximize profits from Jatropha, most farmers decided to go with monoculture farming (Afiff, 2014; Fatimah, 2015). While both national and local government's support encouraged farmers to cultivate Jatropha, Syafri blamed the local government for being more in favor of supporting foreign companies than local ones. "When the Korean company needed to supervise the farmers on how to plant, to nurture and to harvest Jatropha trees, all the local services helped them. None of this happened when we asked their support. The same ignorance happened when we invited the local governance to our opening ceremony. None of them came", said Syafri.

Daeng planted Jatropha together with maize in four hectares of land. He started to be involved in Jatropha activities when Baim's father persuaded him to grow Jatropha. In the past, their relations were informal; they helped each other financially whenever one of them needs help. As most of other farmers in the area, the farming activities were a family business. When I visited his place, I saw that women and kids were peeling Jatropha seeds, while some men were working in the field. During my time wandering in his farm, Baim's father asked about the money he gave Daeng for Jatropha. Daeng admitted to have spent the money for a personal use. Despite this behavior, the businessman was more concerned about Daeng who just went through an eye surgery and asked the farmer to contact him if he needed additional support.

[52]Interview with Damar, January 11, 2011 in JorokBatuLuang, Persiapan, PotoTano.

"We are family after all," said Baim's father explaining his action. This fragment illustrates that for Baim's father and Daeng, Jatropha was not merely business but rather activities to revive their personal relations.

Apart from profit-oriented and informal relations as seen in the case of Syamsul and Daeng, ITE also worked with various institutions, including those without whatsoever connection to biofuel production. For instance, Jatropha activities could be found in a prison in the Dompu district where the prisoners were instructed to plant Jatropha by the prison warden. When I visited the prison, I met Dahlan, a prisoner who was sentenced to 15 years in prison for killing a person during fight. Instead of being locked behind bars, Dahlan acted like a free man, sitting in a gazebo with his wife and his little daughter in a field within unlocked fences (Fig. 1). He said that he earned this flexibility due to good behavior. "Two more years and I will be free," he added.[53]According to Dahlan, Jatropha activities in the prison area started in 2009 when Baim signed an agreement with head of the prison stating the latter's agreement to supply Jatropha to ITE. This agreement was done locally through Baim's activity to create a network with the prison warden. Currently, during the low season, it was only Dahlan and his family who harvest and peel Jatropha, but during harvest season, thirty to forty prisoners came to join them. Until 2010 the prison house sold Jatropha kernels to ITE, and starting from 2011 onwards they also sold it to D1 Oils and C&G Biotech.

Figure 5.1 Damar, his family and Jatropha seeds in a prison in Dompu (Photography by the author, January 2011)

These SETIA farmers share a similar story; since 2010, they started selling Jatropha seeds to other companies. This shift was due to the detachment of ITE from Indosat, which earlier supported ITE through their Corporate Social Responsibility (CSR) program. The CSR program

[53]Interview with farmer C, January 25, 2011 in Dompu.

was executed by providing ITE with advance payment and donated screw-press machines. This cooperation lasted until 2010 when ITE supplied 15,000 liters Jatropha-diesel to Indosat. The corporate secretary explained that Indosat decided not to extend the contract due to the oil price cheaper than Jatropha-diesel price. When I expressed my pessimism on the possible continuity of the business due to high production costs and limited market, Syafri responded that he still had optimism in Jatropha. "Most of our farmers were complaining about the peeling process since it takes time longer than harvesting Jatropha fruits from the trees. I am sure that if we give the farmers peeling machines, we can push down production costs and make the farmers attracted to Jatropha once again." While trying to attract investors to fund peeling machines, he suggested members of the SETIA to sell their Jatropha fruits or kernels to other companies. He was sure that once they start to produce biofuel, the SETIA members would sell their Jatropha again to them.

5.5 Temporal Collaborations or Unsustainable Entanglement?

This paper proposes that the political and academic contexts are not sufficient and that entanglement is needed for Jatropha transformation. Throughout the empirical case presented in this paper, I have shown that apart from the macro factors such as the increase of oil prices, political pressures, and Indonesia's situation as a net-oil importer, there are micro factors that contributed to shaping Jatropha activities in the university and in Sumbawa. These factors include the university *Tridharma*, informal relationships, and the crops market. In this view, Jatropha-related activities emerged out of *entanglement* between heterogeneous actors. The social process of innovation allowed the actors to render Jatropha-oriented activities as new routines. Furthermore, *collaboration* between heterogeneous actors sustained these activities in response to how the material objects (e.g. energy crop, biofuel) are able to support the local context.

The above case study shows that the temporal dimension of collaboration succeeded in creating a protected space where Jatropha is shielded against the existing energy and crop markets, thus allowing Jatropha to transform from "invention" to innovation. A series of continuous collaborations with industry and NGOs allowed ITB to develop Jatropha-related routines. This shows that entanglement emerged not through the same actors but rather through the same type of collaborative activities between heterogeneous actors. This finding resonates with Verhees et al. (2013) who show research on solar PV has been stabilized since the 1950s in the Netherlands despite absence of major growth in the adoption of solar PV in the country. They argue that PV researches were afforded through support from the Dutch government, business actors and non-governmental organizations. These actors allowed research on new

energy to be operated in a protected mode (e.g. through grant, subsidy) where productivity or production cost of the research is not being confronted to the existing market/economic calculations.

The second part of the story focuses on how Jatropha can move from its protection mode to have its first commercial transaction. The empirical case shows that biofuel activities in Sumbawa were made possible by a series of engagement between the West Nusa Tenggara provincial government —the province in which Sumbawa Island is located, and Japan's New Energy and Industrial Technology Development Organization; between Dadang of ITB and a Sumbawa entrepreneur Syafri; between stated-owned Indosat and ITB; and between Indosat and Syafri's company. These various collaborations allowed knowledge of Jatropha to travel from the university to Sumbawa, and to turn into commercial transactions. However, in contrast to a series of collaboration in the university that leads to entanglement, collaborations in Sumbawa only lasted temporally depending on how biofuel activities fit the existing context. The empirical evidence suggests that the difference lies in the presence (or lack thereof) of a set of governed events that facilitate the continuity and coherence of collaborations, including the possibility to have a socio-economic environment that allows biofuel in Sumbawa to avoid direct competition with other energy sources.

5.6 Concluding Remarks

This paper aims to contribute to understanding innovation based on the STS concept of entanglement and collaboration. Specifically, the concept provides an analytical framework that allows the observer to capture the duality of actors and their contexts. By applying the concept of entanglement as the analytical framework, I draw the following conclusions.

First, this paper demonstrates that entanglement is a necessary condition for biofuel innovation in Indonesia. It shows that the transformation of Jatropha knowledge from inception to commercial transaction was facilitated by a series of incremental collaborations between relevant actors and groups. In one case, the energy company, which was supposed to stabilize these scattered collaborations to support its biofuel business, did not manage to survive against harsh pressures from the energy price competition and high production costs. However, in other cases, entanglement emerged in the university where Jatropha-related activities developed through interactions between heterogeneous actors who were committed to Tridharma principles of education, research, and community services

This brings to the second point. Disconnection between Jatropha research and its implementation in the Indonesian context resembles the Mode 1 of knowledge production

where an application of Jatropha research was separated from the context where the research was produced. This disconnection, however, was responded by entanglement that arose between different actors at ITB's Center for Research on Energy and international agencies such as United Nations Environment Program, the U.S. Agency for International Development, and the World Bank. Also noted was entanglement at the institutional level between ITB and the central government where the latter provided research grants for the former to conduct biofuel research and development. As a way to overcome this disconnection, one would call for a more demand-driven research in which knowledge is produced based on what the local people and industry had demanded. Another way is to go for a supply-driven research where it is critical to develop alternative fuel and more preferable, a sustainable one, considering Indonesia's shifting position as net oil importer in 2004. The empirical case presented here shows that rather than having an 'Ivory Tower' syndrome, the observed biofuel engineers performed their actions on real-world problems. What kept their activities from being fully materialized and achieving its goal were the pressures from the energy market. This finding suggests further research on relations between universities and industries in the global-national context.

Third, the concept of entanglement is helpful to shed light on the duality of actors and their contexts. As demonstrated in the paper, the actors were able to conduct Jatropha activities due to strong influences by an institutional factor, that is the obligation to implement the university *Tridharma*. Thus, apart from teaching and doing research, they were active in policy advocacy while at the same time being involved in the entrepreneurial activities. The latter activities were strongly justified by the university *Tridharma*, as off-campus programs are considered part of community service. Despite the general understanding of Tridharma principles, in reality each actor may have different ways of interpreting them, particularly on community service. These differences appear between Dadang who preferred focusing on policy advocacy for biofuel production, while Pratikto was more concerned on the business aspect of biofuel innovation. Apart from giving the actors freedom to adjust to the local context to a certain degree, this local context may also limit the actors' activities, for instance when Indosat did not extend the contract with ITE due to its unreasonable price compared to fossil fuel. It suggests that local contexts allow actors to take autonomous actions to a certain degree. However, when their strategy encountered an unfavorable socio-economic environment, their ability to accomplish their economic goals through new innovation began to decline.

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6. Conclusions

6.1 Introduction

This chapter summarizes the content of the foregoing chapters by providing substantial answers to the research questions. It also reflects on the benefits and limitations of studying transition in action, by both relating the study with other relevant research in the field and discussing its implications for understanding the complex interdependencies between agency and power in transitions. The aim is to contribute to the transition literature by studying how transition in action operates in settings where boundaries of a societal system such as a regime are not well defined. In summarizing the evidence of this thesis, I return to the three concepts of non-linearity, multiplicity and (non-human) materiality to improve the understanding of agency and power in transitions. I begin this chapter by presenting the thesis' empirical contributions (Section 6.2), which are then consecutively followed by theoretical contributions (Section 6.3), methodological implications (Section 6.4), and avenues for further research (Section 6.5).

6.2 Empirical Contributions

This dissertation answers the empirical research question *why did most small-scale biofuel projects in Indonesia stall despite much political and financial support?* It contributes to a broader understanding of the interplay between two settings (or regimes): in the first, small-scale biofuel projects perform in a socio-technical setting of the energy sector; and in the second, the projects perform in a rural development setting constituted by multiple interdependent routines (e.g. farming, agricultural laboring, attending traditional ceremonies). The projects were planned based on the central government's assumptions that these two settings can be mutually reinforcing and therefore, allow Indonesian actors in the agricultural/rural development sector to shift to biofuel and yet also supporting a sustainability transition in the energy sector. Contradicting these assumptions, the study shows that the top-down approach adopted by the central government to reform the energy sector by mobilizing political, financial and also technical supports to rural areas were not (made) compatible with the existing multiple routines.

The thesis shows that in cases (Chapter 2 and 4) where the projects were able to survive for an extended period of time, they had been locally re-designed through association with new regimes such as textile production. On one hand, these associations allowed rural actors to get additional income by attaching themselves to an energy crop. On the other hand, the projects ended up deviating from the central government's aim to produce renewable energy since the current energy crops were partly used for non-energy purposes. These and other differences

between how the rural actors performed the projects and their design by the central government demonstrate the emergence of non-linearity between project design (by the central government) and its implementation (by local governments and many other rural actors).

In cases where the projects were not able to survive (Chapter 3 and 5), the projects tried to follow the central government's design faithfully without taking into account the agencies in the local/rural settings, despite the active resistance posed by them to the government's plans and designs. For example, the energy trees (as afforded by their local/rural settings) 'resisted' the government's approach by not providing cost-effective feedstock for biofuel production. They ended up producing much less fruit than the amount predicted and demanded by the scientists and policy makers. This resistance also highlights the multiplicity of an actor in a project, which is enacted not only by the central government's design and by its obedience of the government's orders but also by other networks such as nature (e.g. steered by season, soil condition) and cultural practices of which it forms a part.

In sum, contrasts between cases that stalled and survived provide the following answers to the empirical research question. First, the projects stalled due to local actors' activities in trying to faithfully follow the generic design proposed by the national government without taking into account the rural setting. Second, the projects stalled due to actors' inability to take into account elements of the projects such as electric generator, oil press, energy crop and the processing machine. The cases show that at the beginning, the projects were considered as a black-box counting for one and not for their parts. However, once the national government decreased their direct intervention towards the projects, these elements started to turn into a complex network where all of the elements tried to escape from the biofuel network by re-attaching to their initial networks. These multiple networks allow the projects to betray their initial objective to contribute to energy transition. Finally, the projects stalled due to the resistance of the material (non-human) actors against following of the central government's design of the projects. The cases shows non-human agencies contribute in shaping a configuration that works, but not according to the government's or the scientists' plans. In the scientists' laboratory, the energy crops were performed through a series of calculations and comparisons. These numbers were black-boxed by the central government's adoption of the most optimal results in their policy designs. In the actual rural agrarian settings, the black-boxes were opened through the energy crop performances in producing biofuels, which turned out to be much lower than the central government's predictions.

This conclusion provides an alternative to economics explanation, which argues that small-scale biofuel projects, especially one that is based on Jatropha, were stalled due to change

in the international energy price, which made the energy crop(s) initially promising to become plainly uncompetitive. As an alternative, it provides a counter to the 'complying' argument suggested by Achten et al. (2009) where rural actors were suggested to involve in Jatropha development through inter-cropping and pastoral system. Rather than following this line of argument, the dissertation shows that the small-scale biofuel projects were not only an economic case but rather are a web of relations of social, technical and cultural traits. It shows that compliance was not practiced by making the small-scale biofuel project a success according to the initial design, but rather a 'success' or a configuration that work to support the local interest (e.g. Chapter 2). The concept of non-linearity allows the analysts to show how an active mobilization allows a local entrepreneur to shift the national government program on renewable energy to produce oil for non-energy market. Therefore, rather than using political terms of success and failure, this dissertation uses the term stall. It explains the situation of the project but it does not add positive or negative values to the situation since success and failure depends on the eye of the beholder.

6.3 Theoretical Contributions

This dissertation explores the conceptual research question of *how can concepts of non-linearity, multiplicity and materiality improve understanding of transitions in action, and in particular the role of agency and power in them?* In articulating these concepts, the dissertation attempts to shed light on issues of agency and power in transitions. Below I match findings from the empirical materials in relation to issues of agency and power to show how the concepts of non-linearity, multiplicity and materiality improve the understanding of these issues in transitions.

6.3.1 Transition as continuous actions that produce non-linearity

Linearity between design of the projects and their implementation is determined by the power of the designer of the project, in this case the central government, to steer the local government bodies, emerging niche markets and established farmers to follow their design, while reacting to these actors' attempts to re-design the project. As suggested in Chapter 2, the innovation projects' designs did not provide adequate guidance for dealing with possible unintended effects. This absence of guidelines allowed one of the local actors, the entrepreneur, to create a non-linear trajectory by forming a new network that benefited his company and was different from the one formulated by the initial designers of the innovation projects. The trajectory is non-linear not only due to differences between design and implementation of the project, but also due to changes in the national politics, which affected the national government to reduce their involvement in biofuel development after a period of time.

The case shows that non-linearity in innovation emerges in and through two sets of practices. The first set of practices refers to the central government's actions to mobilize political and financial capital to support innovation projects in the villages. These actions shielded the projects from mainstream selection pressures, by providing subsidies, capital to hire labors, organized support from the village governance apparatus and the district governments. However, these shielding activities were not sustained due to the inability or disinterest of the local actors to continually follow the projects' guidelines or policies, adapting them into their everyday routines. The case shows that after financial support from the central government ended, the village apparatus was left with machines to process energy plantations' harvest into oil, but with no biofuel market, or even options to initiate activities to build a market, no capital to run the project and little knowledge about what to do with these machines. This situation demonstrates that shielding activities are always under trial, enclosed by a dialectic between the mobilization of support and emergent forms of resistance such as those arising out of tensions or misalignments between the new network of biofuel machines with village lands/farmers and the extant agrarian network of farmers with food crops/markets.

In these practices, non-linearity is produced not only due to different practices of biofuel between the central government, as designers of the original projects, and village actors as users but also on how these different actors react upon biofuel practices. As I mention earlier, the generic design proposed by the government did not provide adequate guidance to deal with unintended effects. Contrast between cases that stalled and survived suggests actors' opposing ways in performing design. In cases where the project stalled, design was situated as a script to forecast the future circumstances. Whereas in cases where the project survived, the design was used as an entry point for interaction; a prescription of setting the actors both what it limits and what it permits. The latter allows actors to shift their position towards biofuel depends on how the activities may benefit them.

The second set of practices emerged as a 'local' response to decrease of the central government's direct support to the projects. This set of practices focused on a local entrepreneur's actions to gathering the leftovers of the government's projects (biofuel processing machines, local governance apparatus) and building new networks, also using the entrepreneur's prior actor-network that consisted of peeling machines and farmers brought over from two other districts. Gathering of these resources into new networks also allowed the entrepreneur to shield and to nurture his own social enterprise against local competitors while, at the same time, attempting to survive in a non-protected market through diversification (e.g. entering textile and research markets). At the national level, the entrepreneur followed a fit-and-conform strategy in

framing his business as part of the central government's project to get financial support. At the local level, the entrepreneur followed a stretch-and-transform strategy where the company 'betrayed' the project's design by extending biofuel activities to the forest conservation sector (together with the State Owned Forestry Enterprise), new university-led experiments and the textile industry.

Non-linearity in these two sets of transition practices also suggests that the ability to enroll heterogeneous actors to support a new renewable energy resource is afforded through the acts of representation. This representation covers not only speaking on behalf of other actors but also through making the design to speak on behalf of their future self. These acts of representation allowed particular actors (e.g. scientists, central government, entrepreneur) to mobilize more actors to support their design and thus, performing power. Power, as making heterogeneous actors to follow a particular script is afforded by actors' agency, of having relations between heterogeneous actors that perform. The analysis suggests that agency *facilitates* power. It is through the emergent effect of actors' relations, actors are able to perform power. However, since actors' agencies also allow them to do new things that may be unexpected, agency also *limits* power. These conflicting relations of agency and power suggest that transition is always in the making since it requires continuous tensions to facilitate actors to follow particular design or script and to resist a singular script. In this conceptualization, power presents itself not in the form of an actor endowed *a priori* with requisite power but rather is an outcome of a process of negotiation and constant adjustments in a specific network (e.g. biofuel) to changes in other networks (e.g. national political network; district government; village apparatus).

This conceptualization suggests that inequality of power among actors is an emergent property determined by the (in)ability to mobilize other actors. Only some actors are able to exert and gain this form of power: for example, the entrepreneur was able to gain power building on and adapting the central government's project, through the mobilization of other rural actors, while the village farmers could not do the same.

6.3.2 The Multiplicity of Transition Actors Leads to Unexpected Outcomes

The chapters show multiple forms in which biofuel entities existed. These multiple forms include fantasy, a part of reality which allows actors to relate with biofuel in certain ways and the socio-technical network of biofuel. Throughout the chapters, I have shown that these forms, through their differences, allow symbiotic interactions, domination or disconnection between biofuel-related actors. It shows that actors' ability to move an invention from the scientists' laboratory to other places was afforded by a matter of opportunity due to increase of international oil price, financial and political crises. These events allow the multiple forms of biofuel to interact

symbiotically but only as far this connection benefit the actors in their multiple forms such as how the socio-technical network of biofuel meets actors' fantasy about a wonder crop. The chapters show that both fantasy and socio-technical network of biofuel were continuously being adjusted and thus, creating outcomes that were completely different than what were designed. The situated outcomes, which emerge as matter of opportunity, place design not as a tool to describe the future but rather to allow actors to gather and to contradict the design.

Chapter 3 elaborates the multiplicity of biofuel actors by showing how the proponents of a biofuel project mobilize fantasies as ways to attract other actors to support the project. The case demonstrates that multiple enactments of actors in a biofuel project hang together through ongoing configurations of fantasies. Articulating biofuel practices as fantasies, the chapter shows that actors included the biofuel project in their daily routines when the project met all the dimensions of fantasies such as being able to function more effectively; assume actors as having no selfish interest; being able to address multiple problems that are not necessarily go along together; and only highlighting the positive part. The case also shows that when the project failed to meet all of these dimensions, actors started to detach their connection from the project.

Chapter 5 elaborates multiplicity in transition practices by following how biofuel travels from a laboratory to an industry. It demonstrates that biofuel's ability to travel was afforded by actors' multiple values such as the desire (and pressure) to carry out *Tridharma* norms to teach, to research and to do community service; to optimize profit and to have corporate social responsibility (CSR) program; and to help relatives who are in need. These multiple values allowed the biofuel project to travel in a protected situation, in which the project could survive without competition. However, the case showed that the protected situation only lasted temporarily. Biofuel was only a one-time project for the CSR program, the engineers who developed the biofuel reactor could no longer help the business aspect of the biofuel project and the relatives network that allowed the project to be accepted by the local farmers turned out to be counter-productive for farmers' income.

Multiplicity in these transition practices suggests that multiple versions of biofuels coexisted. A statement like "mobilizing biofuel to increase people's welfare" represents a small part of the reality that stimulated the Indonesian government's attempts to mobilize resources to support biofuel production. This statement was obeyed by the Ministries and provincial governments between 2005 and 2009, when they were involved in biofuel development. However, after many villages had implemented the projects, the statement faced a counter-statement that claimed that biofuels were unprofitable. These realities, of increasing people's welfare and being unprofitable coexisted alongside each other and affected actors unequally,

depending on their relationship to the statement. For instance, despite many failure cases in small-scale biofuel program (e.g. Amir et al., 2008; Fatimah, 2015), statement to mobilize biofuel to increase people's welfare was still used by the central government apparatus to promote small-scale biofuel production in different part in Indonesia (e.g. Fatimah et al., 2015). This phenomenon suggests that biofuel failures in specific locations such as Grobogan and Mandalasari coexist at the same time with 'biofuel for welfare' in places where biofuel was going to be started such as in Purworejo and Kebumen. This fragment suggests that power to mobilize other actors is afforded by preventing actors from knowing the risk of biofuel. Power therefore limits actors' agency not only through mobilizing resources but also through disconnection with places where biofuel failed. It creates a negative power that works through errors and disturbances of understanding the reality of biofuel.

6.3.3 Material Agencies Shape Transition Practices

In transition studies, the role of non-human entities is implied through the definition of technology as 'configurations that work' (Rip & Kemp, 1998:330). The definition emphasizes an inherent relation between the technical and the social, in which the social context plays a significant role in making technology fulfill its functions (Geels, 2005:11). It focuses on how human actors, through learning, networking and articulating expectations afford socio-technical change. While this conceptualization includes technology or non-humans in general in the analysis, performance of these non-humans is mainly determined by human actors. The nonhuman materials then simply follow and implement what humans expect of and desire from them.

This dissertation argues that understanding socio-technical change without a study about the material agency of biofuel actors, which includes the energy crops and machines to process the crops, cannot be adequate. This material agency of biofuels or any other new technology affords what an interrelated human actor can or cannot do. Thus, these material agencies do not exist somewhere out there, detached from human actors, but rather they are embedded in webs of humans and nonhumans. The latter include categories (e.g. the notion 'biofuel'), tools for scientific experiments (e.g. methods of turning energy crops into data), elements of agricultural practices (e.g. those used in harvesting energy crops) and in fuel processing (e.g. machines).

Chapter 4 argues that material agency is connected to the exercise of power in relations, which shapes the stabilization and de-stabilization of the socio-technical networks. The Indonesian biofuel case shows that even if biofuels had been produced with the help of scientific devices that were quite transparent, the numbers produced for policy were reassembled according to the current political situation. Moreover, these numbers were being reassembled in

the local performances where the notion 'biofuel' did not refer only to the numbers produced by the policy makers but also to the numbers produced by the trees. For instance, yields predicted by the government (i.e. FORDA, 2008) were not realized in the forest of actual Calophyllum trees: the harvesting time for the energy crop was predicted on the basis of periodic dry and wet seasons and a fixed ratio between kilogram of seeds and oil produced in the laboratory, all of which did not get achieved in the actual factory in the field. The case shows that relations between local government, farmers and biofuel entrepreneurs in the biofuel project were shaped by the agency of trees, seeds and factory technologies. These latter 'biofuel' agencies reassembled the numbers produced by engineers and policy makers.

The chapter suggests that the material agency of biofuel cannot be seen simply 'out there'. However, it cannot also be seen as the effect of language or social performances (Butler, 1993; Lippert, 2013). Biofuel practices were being enacted through tensions between activity of interacting with biofuel materials (e.g. seeds, soil, oil, machine) and activity of representing (e.g. producing scientific paper, policy documents). Material agency emerges through tensions between doing and representing and also through activity of moving one representation document to another space. For instance, scientific calculation in academia was made to travel to the policy makers without an understanding of the assumptions that are embedded in academic outputs. The analysis shows that power accumulation is centered in localized activities such as cultivating, harvesting or producing scientific results. It shows that power facilitates agency through intersection with other forms of power and vice verse, limit agency through disconnection.

6.3.4 Relations between Evidence, Agency and Power

The dissertation argues that the notions non-linearity, multiplicity and materiality (nonhumans) enable an improved understanding of agency and power in transition. The empirical chapters (Chapter 2 to 5) show that this improved understanding is made possible through approaching transition in action as a series of a set of actions. This discrete approach slows down the analysis by multiplying the source of actions; by providing a break to reflect on actors' unity and by adding voices to marginal actors such as seeds, trees and woman (Chapter 4). In the following table, relations between the three notions with issues of power and agency are elaborated. The table shows that affordance to do new things emerges through tensions between multiple agencies, between designers versus users, between actor-networks that adopt different values or between the physics and semiotics of an object. It shows that the notions non-linearity, multiplicity and materiality offer an incoherent account of slowing down the analysis, while at the same time, share a coherent account about agency and power (Chapter 1).

Table 6.1 Evidence and its relation to agency and power in transitions

	Evidence	Lessons about agency and power
Non-linearity	Non-linearity emerges in difference between design and implementation of the project and also between actors' position towards biofuel in different periods.	Agency *facilitates* power through interactions of the heterogeneous actors that allow a particular configuration to accumulate more supports than others. It also *limits* power due to possibility of actors' resistances. These two faces of agency contribute to non-linear transition.
Multiplicity	Multiple versions of biofuel actors coexisted, some stronger than others. A statement like "mobilizing biofuels to increase people's welfare" and "biofuel is unprofitable" coexisted in different actor-networks. These networks impacted actors unequally, depending on their relation to the statements.	Power limits actors' agency not only through preventing certain information to enter the projects but also through mobilizing particular values and assumptions that prevent counter-arguments to enter the projects. Agency is afforded through interactions between multiple versions of biofuel where each version is built on different value and assumption.
Material Agency	The material agency of biofuel emerges through physical interactions between human and non-human actors of experimenting and cultivating and through black-boxing (or stabilizing) variety of these physical interactions into text (e.g. papers, policy document and business model).	Material agency facilitates power through the activity of black-boxing, while it limits power through tensions between physical interactions of human and non-human and the black-boxing activities. Material agency multiples actors' source of action, which initially only focuses on human actors.

6.4 Methodological Implications

> *"If ANT is a theory, then a theory helps to tell cases, draw contrasts, articulate silent layers, turn questions upside down, focus on the unexpected, add to one's sensitivities, propose new terms, and shift stories from one context to another" (Mol, 2010:253).*

This dissertation uses actor-network theory (ANT) as a methodology that performs an experimental inquiry to investigate transition practices. It performs ANT as a toolkit to help to

tell cases, which instead of offering a coherent framework allows observers/researchers to have multiple realities (Law, 2004; Law & Urry, 2004; Mol, 2010). This conceptualization produces 'multiple realities' via performing different methods to relatively similar cases. By adopting multiple frameworks, this dissertation addresses the issues of agency and power not only through the method offered by a particular frame, but also through coherent and incoherent accounts among different frameworks. The latter is afforded through contrasting multiple realities that are constructed through the frames. These multiple frames do not seek coherence rather it craft the overall understanding through dissonance.

Combination of protective space (Smith & Raven, 2012) and script (Akrich, 1992), as seen in Chapter 2, creates a conceptual framework that focused on change in the discourses, business model and actions of the biofuel project and how these changes happen. The analysis shows that actors' agency to do new things are afforded through non-linear behavior where actions of the district and village actors cannot be expressed as an outcome of the designers' (the national government) actions. This version of explaining transition as non-linear is afforded by contrasting actors' activities to support the small-scale biofuel project via protective space and actors' activities to react against those activities via script.

Chapter 3 combines fantasy (Bormann, 1985; Sovacool & Ramana, 2015) and value (Boltanski & Thévenot, 1999) to understand how fantasies of Jatropha impact research and innovation and how actors' values shape Indonesia's biofuel trajectory. Actors' ability to mobilize other actors to follow a particular script is addressed through material fantasy, of shifting to a new script and through multiple values, of conserving existing scripts. While actors' ability to break from a particular script is addressed through intersection between values, either through accumulation where one strengthen the other or through competition where one weaken the other. This version of explaining transition as multiple is afforded by including empirical materials about actors' fantasies on Jatropha and how these actors manifest these fantasies into their values.

Chapter 4 uses the notion frictions—defined as material resistance or recalcitrance encountered in processes of transformation, to study the role of nonhumans in constituting 'implementation' and calculative-discursive practices in development projects and programs. The analysis shows that nonhumans play a central role in making and unmaking asymmetric relations of power in practice and by constituting practices that diverge from prior expectations, problematize linear understandings of 'policy implementation.' This version of explaining transition as being enacted by material agency is afforded by incorporating non-human actors as sources of actions.

Chapter 5 combines entanglement (Callon & Latour, 1981) and its opposite, collaboration to understand actions as being performed through negotiations between actors and their contexts. The analysis shows that local contexts allows actors to perform their preference up to a certain degree, but when their preferences interact with others' preference and started to threat the exiting context, their ability to perform their preference start to decrease. This version of explaining transition as a series of continuous negotiations between actors and contexts is afforded by looking at activities that allow actors to create a new localized context and activities that conserve the existing contexts.

These various frameworks show that methodologies are productive in constructing different conceptualizations of agency and power. While this dissertation adopt a singular definition of agency as emergent effect of actors' relation and power as ability to mobilize actors, different frameworks allow production of different understandings on how agency and power work in practices. Throughout the chapters, I demonstrate that methodologies are productive in including and excluding data and thus, enact the way we construct social realities (Law & Urry, 2004) and that one cannot understand agency and power without knowing its reference devices/concepts (cf. Lippert, 2013). The multiplicity of agency and power in practice hang together through a singular definition of what these notions refer to. Key to this singularity is not coherence of the definition but rather elasticity to accommodate multiple practices of agency and power and their various reference devices.

6.5 Future Research

The transition practices analyzed in this dissertation are limited to year 2002 to 2014. In this period, proponents of the biofuel program and small-scale biofuel projects transformed the central government's standardized model to the local context. This transformation affords non-linearity between design and implementation and also between actors that enter and drop off from the project, coexistence of multiple actor-networks enacting different interpretations of the governmental policy plans and for materials to shape innovation practices. The cases demonstrate relation between agency and power as mutually constitutive: that agency is afforded through and against power. These observations are not presented as general. To gain a rich understanding of agency and power in innovation practices, much more comparative research in the following traditions are needed.

1. Longitudinal studies

   This dissertation is built on a short period of time. It demonstrates how transition in action works on ongoing configurations and fuzzy boundaries. To prove that these characteristics

work in general and not only in a short period, longitudinal (30-40 years) period is needed. Geels (2010) for instance, suggests that actor-network theory focuses on 'innovation in-the-making' and thus, ignoring the innovation once it is stabilized. While this remark is intended as a critique from a stability-seeking perspective, I propose that stability is rather a temporal situation and therefore, can always be investigated through transition in action. This proposition is in line with Callon (1998) that argues ongoing configurations or 'hot situations' become more common than stabilized or 'cold situations'. In performing longitudinal studies, however, one has to take into account historical text as inscriptions, a translation of reality (Law & Urry, 2004; Nimmo, 2011). This strategy allows text to be taken into account as practice of making historical reality, in which mediates relations between subjects. Association to text as a translation of reality brings this type of longitudinal studies close to literary theory.

2. Comparison of transition practices in European and non-European settings

   The empirical evidences for this dissertation is built in Indonesian setting that are quite different from the (European) countries where transition studies are traditionally situated. The dissertation shows that in practicing transition, the Indonesian government combined an interventionist rural developmentalist approach — by mobilizing resources and instructing state-owned enterprises to become the market for the new businesses with a market-based approach where the new businesses are expected to be able to compete with existing products after three months of protection. Further study on how transition in action performs in similar other hybrid European and non-European settings will contribute to a better understanding of agency and power in transitions.

3. Material economy

   This dissertation shows that the central government's design failed to meet its prescription and thus, the design has to be rearranged or transformed. This finding suggests continuous negotiations between designs that manage to produce repetition (e.g. of political stability, welfare) and designs that are constantly deal with surprises, which designers or policy makers sometimes able to deal with, but only temporally such as during protection (cf. Callon, 2007 on performations). For the design to be implementable, the actors have to be able to perform it. These performances are made not only by a network of incentive, crops and institutional regulation but also through a set of iterations of experimenting how the set of these materials are being de-scripted of pronunciation by these actors to perform the network. Performative relation between design and practice calls for a further research on material economy in transition practices where actions are shaped not only by human actors'

interests and goals but also by various material and semiotic devices associated with the human actors, including the economics e.g. the performativity of a mathematical formula (Black-Scholes option pricing model; Input-output model) in shaping our economic behavior.

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Summary

This dissertation examines the relation between agency and power in transition. In articulating the relation between agency and power, this dissertation focuses on a biofuel self-sufficient village program. The program aimed to sufficiently fulfill the energy demand within the village and to increase the local energy production capacity. As part of the program, the central government mobilized financial grant, technical support and training to more than 500 villages in Indonesia. Two main research questions are raised in this dissertation: why did most small-scale biofuel projects in Indonesia stall despite much political and financial support? And how can concepts of non-linearity, multiplicity and materiality improve understanding of transition in action, and in particular the role of agency and power in them?

The innovation practices analyzed in this dissertation are limited to year 2002 to 2014. In this period, proponents of the biofuel program and small-scale biofuel projects transformed the central government's standardized model to the local context. This transformation affords non-linearity between design and implementation and also between actors that entered and drop off from the project, multiplicity between different actor-networks and for materials to shape innovation practices. The relation between agency and power is mutual inclusive; interactions between actors that perform allows agency and steer their behavior (by forcing them to coordinate change).

By analyzing the biofuel self-sufficient village program, this dissertation aims to contribute to the transition literature by proposing transition in action that operates in settings where boundaries between different groups of actors are not clear and where relations between them are performed through a hybrid agency and power. This hybrid refers to the principle of performing, making and doing, suggesting that ability to do new things is afforded in and through practices. In other words, agency is exercised in practices, which through these practices allow the establishment of power.

This dissertation relies on multiple sources of evidence a) 60 in-depth interviews with highly knowledgeable informants from universities, entrepreneurs, farmers, the local governments in Bandung, Bogor, Grobogan, Yogyakarta, Kebumen, Purworejo and Sumbawa and national policy makers in Jakarta; b) participatory observer in Yogyakarta, Grobogan, Kebumen, Purworejo and Sumbawa for a total of six months spread across June 2007 and May 2012; c) one national workshop (attended by representatives from 15 institutions), a local focus group discussion in Purworejo (attended by representatives from 30 government/local

institutions) and a local workshop in Yogyakarta (attended by representatives from 10 local institutions); and d) written materials.

As a way to unpack the relation between agency and power in innovation practices, this dissertation employs multiple frameworks developed from transition studies, communication studies, development studies and science and technology studies. These multiple frameworks are adopted as a way to destabilize the analytic process and to avoid a priori frame. Through adopting these frames, the dissertation affords assessment to be measured based on values of each studies.

About the Author

Yuti Ariani Fatimah was born on October 8, 1983 in Bandung, Indonesia. In 2006, she received her Bachelor of Science in Mathematics and in 2008, her Master degree in Development Studies (with honors) both from Bandung Institute of Technology. In December 2009, she continuous her interdisciplinary journey by taking a doctorate degree in Twente Centre for Studies in Technology and Sustainable Development, University of Twente where her academic interest intersected with Transition Studies. This intersection created a detour in her PhD life. In April 2011, she started her PhD at the School of Innovation Sciences at Eindhoven University of Technology to study Transition Studies and to strengthen her long-time interest in Actor-Network Theory. Cross-over between Transition Studies allows her to elaborate power struggle in an on-going transition process, especially in the context of renewable energy in Indonesia.

She is now a researcher in the School of Architecture, Planning and Policy Development, Bandung Institute of Technology and a consultant on technological and developmental issues. Her line of work covers Science and Technology Studies, Transition Studies and Development Studies with methodology such as actor-network theory, ethnography, system dynamics modeling, and mix method between qualitative and quantitative approaches.

Yuti likes to combine being in the academia and being involved in the policy making processes. Apart from doing research, she is a reviewer for *Energy Research & Social Change* and *Geoforum*. In the policy making processes, she works closely with the Indonesian National Development Planning Agency on climate change modeling and with the Ministry of Communication and Informatics on smart village in Indonesia.

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