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Stimulating renewable energy transitions in remote developing contexts: the role of newly-formed local institutions

A case study of the Sumba Iconic Island initiative in Indonesia

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Cover photo: *a local distributor proudly showing the solar home system he leases to his neighbours.*

Summary

Renewable energy transitions provide promising solutions to improve livelihoods of one-billion people in remote areas without access to electricity, whilst mitigating negative impacts of global warming. Yet, the promotion of decentralised renewable energy systems faces challenges. Theoretically, scholars are struggling to combine European-based transition theories with global South-oriented development approaches. Practically, users struggle to adopt foreign technologies and face financial and managerial obstacles to establish renewable energy markets. Both theoretical and practical fields point to the importance of newly-formed institutional structures to locally embed renewable energy projects, pursued in what scholars call experimental niches. Yet, empirical research on how they could effectively do so is lacking.

Therefore, this research addresses the question: *How can newly-formed institutional structures contribute to local societal embedding of renewable energy niche experiments in remote developing contexts?* This question is answered through the lens of a case study of a multi-actor renewable energy programme on a remote Indonesian island. Qualitative data was gathered to analyse the roles of three newly-formed institutional structures - a cooperative, social enterprise, and private service company – that offer solar, micro-hydro, and biogas technologies. The analysis was guided by a novel literature-derived framework, including insights from strategic niche management and learning-based development approaches.

Findings show that the formation of a complex network – consisting of various regional institutions that work with local agents - is paramount for local embedding of the renewable energy niche. First, the network serves the function of an intermediary platform, connecting NGO resources with vulnerable people in remote communities. Second, the network is strengthened by trust-based and complementary relations amongst local institutions that stimulate collaboration. Third, this complementary network enables market creation that targets various consumer segments, by offering a range of technologies through different distribution points. Yet, it proves more difficult for local agents to stimulate participation of the population. Fostering bottom-up learning processes is found crucial to ensure proper social configurations of foreign technologies. The thesis concludes that the formation of institutional structures requires extra attention to their management capacities, to promote social learning. Overall, the newly-formed institutions are in the key position to make renewable energy niches locally embedded. This research makes a first attempt to outline the ‘right’ building blocks of institutional structures, that benefit both niche development and inclusive participation.

Key words: Renewable energy transitions, Developing countries, Institutions, Strategic niche management, Learning-based development

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List of abbreviations

CSO	Civil society organisation
FGD	Focus group discussion
IDR	Indonesian Rupiah
MCA-I	Millennium Challenge Account Indonesia (fund)
MLP	Multilevel perspective
NGO	Non-governmental organisation
PLN	Perusahaan Listrik Negara (Indonesian state electricity company)
PV	Photovoltaic
RESCO	Renewable Energy Service Company
SII	Sumba Iconic Island
SNM	Strategic niche management
YRE	Yayasan Ruma Energi (social enterprise)

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Chapter 1: Introduction

Renewable energy transitions towards alternative models for energy pathways are urgently needed throughout the world. Whereas developed countries focus on moving away from fossil-based energy systems, in developing countries efforts have been predominantly concentrated on providing access to energy (Marquardt et al., 2016). Providing access to energy to the world's poor is crucial in fostering human and economic development. Affordable, reliable and clean modern energy services are fundamental to poverty reduction, health improvement, and increased economic productivity (Pedersen et al., 2017). Currently, 14% of the global population still lacks access to electricity, of which 84% lives in remote areas in developing countries (IEA, 2017). Yet, a lack of existing infrastructure and declining costs for renewables now provide opportunities for developing countries to leapfrog into the low-carbon era (Marquardt et al., 2016; Pedersen et al., 2017; Wieczorek, 2018).

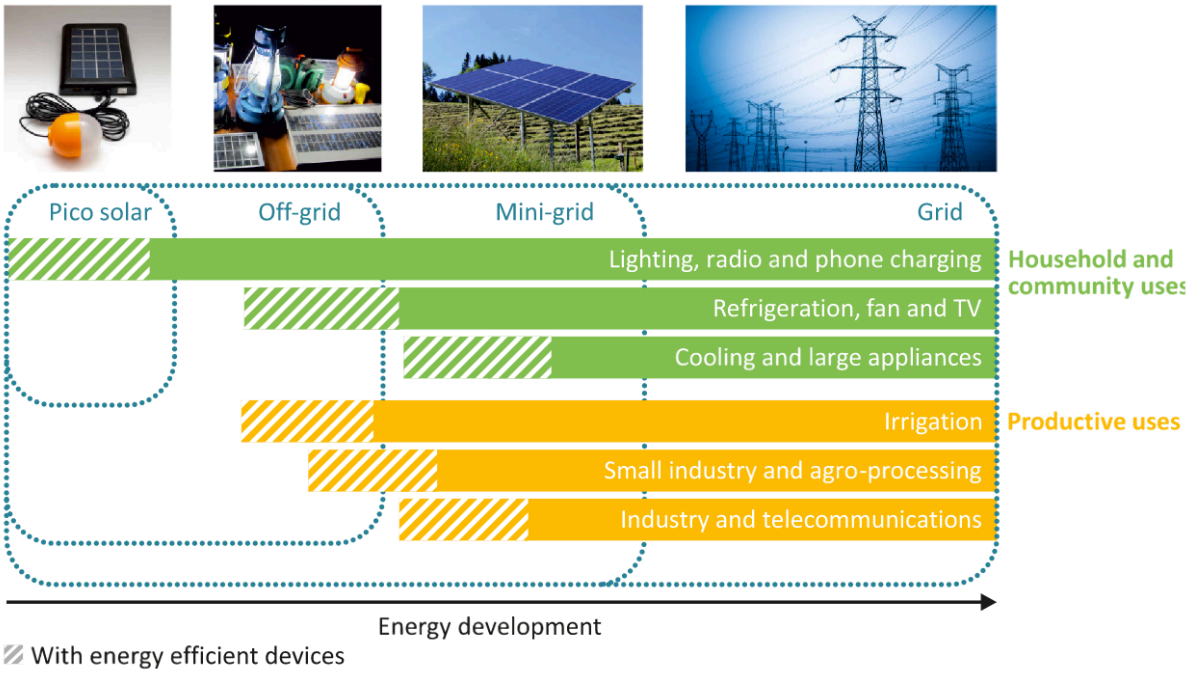

Figure 1. Electricity access and illustrative technology options (IEA, 2017).

Decentralised renewable energy systems are showing particular promise as a cost-effective way of providing energy access in remote areas in developing countries, where household energy needs are generally small (Byrne, 2011). As visualised in Figure 1, the number of pathways to attain energy access are enhanced by off-grid technologies, including solar home systems, pico solar installations and mini-grid technologies using solar, hydro, wind and biomass/gas power. The International Energy Agency (2017) predicts that 90% of remote areas in developing countries will rely on such decentralised renewable systems in the future.

Consequently, the question arises how transitions towards renewable energy systems will take place in these remote developing areas. Whilst international donors have promoted the

uptake of off-grid renewables in developing countries for decades, governmental agencies, venture capitalist and social entrepreneurs are now seeing opportunities as well. This is mainly related to ambitious government renewable energy policies, new business models, and changing market conditions that have made decentralised energy systems commercially viable in places that were previously too costly to reach (Blum et al., 2015; IEA, 2017; Marquardt et al., 2016). As a result, a shift can be observed from isolated donor-supported projects concentrating on single energy technologies, towards long-term multi-stakeholder energy transition programmes focusing on a wide range of tailored technologies as well as local capacity building efforts (Sovacool et al., 2016).

The field of transition theories has specialised in studying such multi-actor renewable energy transitions (Marquardt et al., 2016). However, established in developed countries, the field has been critiqued of reiterating top-down perspectives of transferring technology developed in the North to the global South. Moreover, it is said to overlook the highly complex local intra-project dynamics in developing countries (Geels et al., 2016; van Welie & Romijn, 2018; Wieczorek, 2018). As a result, Romijn et al. (2010) argue that the main challenge for sustainability transitions is to connect the environmental sustainability agenda – as primarily pursued by transition theories – with agendas of poverty reduction, local community development and capacity building. Various scholars (including Hansen et al., 2018; Ramos-Mejía et al., 2018; Romijn et al., 2010; Wieczorek, 2018) have pointed out an importance of enriching transition theories with insights from bottom-up development approaches. Whilst transition theories provide the system perspective that transitions require, the inclusion of development theories allows a more fine-grained analyses of local institutional, social, and cultural processes that are typical in developing countries and affect social sustainability of renewable energy programmes (Ulsrud et al., 2015).

In practice, the stimulation of renewable energy transitions in remote developing areas also faces challenges. Users struggle to adopt foreign technologies, as local capabilities to install, operate, and maintain technologies are often insufficient (Eswarlal et al., 2014; Martinot et al., 2002). Access to financing, possibilities to learn and experiment with technological and social configurations, and the creation of a viable renewable energy market are necessary to initiate a full-fledged renewable energy transition, conditions that are often difficult to stimulate in remote developing contexts (Martinot et al., 2002; Sovacool, 2013). As argued by Byrne (2011), a first step to instigating renewable energy transitions is to ensure that experiments in niches - where multiple experimental projects interact with the aim to create a successful renewable energy market - are strongly locally embedded.

To locally embed renewable energy niche experiments, scholars from both theoretical fields point to the importance of creating new institutional structures. The creation of a successful renewable energy niches requires local institutions that can stimulate entrepreneurship, enhance learning amongst experiments, and ensure sustainability of the technologies (Ramos- Mejía et al., 2018; Romijn et al., 2010). Similarly, the creation of new local institutions is necessary to ensure local ownership and inclusiveness, overcoming power configurations and empowering local communities (Eswarlal et al., 2014; Oyake-Ombis et al., 2015; van Welie & Romijn, 2018).

Yet, research that specifically focuses on the role of newly-formed institutional structures in locally embedding renewable energy experiences is lacking (Romijn et al., 2010). Moreover, practical applications that combine transition theories with development studies are limited, and researchers call for empirical contributions (Byrne, 2011; Hansen et al., 2018; Wieczorek, 2018). Operating within an overlap between the two scientific fields and practice, this research explores the question: *How can newly-formed institutional structures contribute to local societal embedding of renewable energy niche experiments in remote developing contexts?*

The context of Indonesia provides an interesting case. A renewable energy transition is pursued by a variety of actors, including the government, market actors and development cooperation. However, the country's highly diverse geographical, political and cultural composition complicates inclusive and participatory promotion of energy access (Chelminski, 2015; Reber et al., 2016). This research builds on the experience of an ambitious multi-stakeholder initiative, called the Sumba Iconic Island (SII) programme, in the eastern part of Indonesia. In the SII programme, various non-governmental organisations (NGOs), investors, and government bodies work together to provide 100% renewable energy access for over half a million impoverished people on the remote island of Sumba by 2023 (Hivos, 2015).

Using the SII programme as a case study of a renewable energy niche, this research has gathered qualitative data on various renewable energy experiments (including micro-hydro, biogas, and solar power), managed by three different types of newly-formed institutional structures: a cooperative, a social enterprise, and a private sector service company. The empirical data will be analysed in reference to the role of the three newly-formed institutional structures. Practical advice will be constructed regarding effective institutional building blocks that contribute to local societal embedding of renewable energy niche experiments in remote developing contexts. Theoretically, a novel literature-derived framework is developed to conceptualise local societal embedding, including insights from strategic niche management and learning-based development approaches. Herewith, the research hopes to advance the application of transition theories to developing contexts.

Chapter 2: Theoretical framework

This chapter reviews major debates in the fields of transition theories and development studies in order to conceptualise local societal embedding of renewable energy niche experiments. In particular, the chapter explores how the concept of strategic niche management and learning-based participative approaches can complement each other and highlights the role of newly-formed institutions in locally embedding renewable energy niche experiments. Finally, the conceptual framework is presented.

2.1. Transition theories

To pursue renewable energy transitions in developing countries, new renewable energy technologies need to be introduced. A number of theoretical approaches have evolved to analyse such technological change, broadly categorised as 'technology transfers', 'innovation systems', 'diffusion-adoption systems', and 'learning-based approaches' (Byrne, 2011). These theories focus on single elements of transition processes: respectively, technological capability building, interlinkages between firms promoting innovative technologies, user adoption, and community-level interventions that foster learning. Yet, these theories fail to provide an all-encompassing overview of complex sustainability transitions. Renewable energy transitions go beyond merely delivering one-service technology. They require innovative approaches to energy sector governance, in which enabling environments for technology development and adoption need to be created. Hence, a system view is necessary to study and push energy transitions. The field of transitions theories provides this system view, being able to analyse various technologies and distribution systems, business service delivery models, political economic issues, cultural attitudes and social behaviour (Sovacool et al., 2016).

Within the field of transition theories, various models have been developed to explain how transitions emerge and should be governed. The multilevel perspective (MLP) is the most fundamental model, on which most other approaches are based (Wieczorek, 2018). MLP assumes socio-technical transitions involve processes along three levels, as shown in Figure 2.

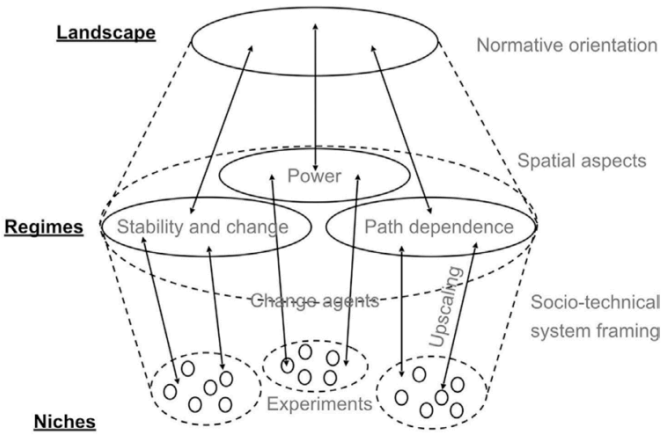

Figure 2. The multilevel perspective model of socio-technical system transitions (Wieczorek, 2018).

The middle level constitutes of socio-technical regimes, generally described as the rules and routines that define the dominant 'way of doing things' (Wieczorek, 2018). The regime level includes the institutions, associations and governance structures that exist within the dominant socio-technical system, in this case the energy system (Osunmuyiwa et al., 2017). An example is the presence of a large state electricity company that generates electricity in coal-fired power plants, selling this for cheap prices to households via a national grid. Regimes often obstruct radical change, as they are characterised by path dependency, stability, and lock-ins.

The upper level is called the socio-technical landscape, including various external pressures that affect transition processes, such as demographic changes, economic growth, wars, or crises. Although the landscape is beyond the direct control of actors, it either stabilises or puts pressure on occurring regimes, the latter making them vulnerable to radical changes (Wieczorek, 2018). For example, negative health impacts or global efforts to mitigate climate change can put pressure on electricity regimes to move away from coal-fired power plants.

Regimes can transform when alternatives are available that fulfil the same societal function. Such alternatives are developed in the lower level, in niches. Niches are conceptualised as protected spaces that facilitate experimentation with alternatives (Wieczorek, 2018). The niche then constitutes of a network of new technologies that are in a nurturing stage (Osunmuyiwa et al., 2017). Through a long process of experimentation in pilots, markets and technologies can develop in a process of co-evolution. For example, clean renewable energy technologies provide alternatives to fossil energy systems. By creating niches in which technologies are actually used, users create or learn about new needs, policy makers can create regulatory frameworks that fit the innovation and industrial actors learn to improve the technical properties and reduce costs (Mourik & Raven, 2006).

Consequently, a transition is defined as '*changes from one socio-technical regime to another*' (Geels & Schot, 2007). Change is oriented towards sustainability, with strong emphasis on environmental aspects (Wieczorek, 2018). However, as noted by Byrne (2011), it proves difficult to point out and analyse existing energy regimes in remote developing areas where energy services were previously absent. Rather, it can be considered that processes of rural electrification regime building are taking place (Hansen et al., 2018). As a result, it is assumed that multi-actor renewable energy programmes are stimulating niche experimentation, for which application of the strategic niche management approach is most suitable (Byrne, 2011; Romijn et al., 2010).

2.2. Strategic niche management

Strategic niche management (SNM) refers to deliberately managing niche formation processes through orchestrating the interaction between various experimental projects (Sengers et al., 2016). SNM assumes that promising technologies are often unprepared to face market competition pressures, hence requiring some form of protection. Technologies are called 'promising' as actors believe the technology will eventually be socially and commercially viable, providing reasons to protect it and invest efforts to develop it. Thus, protection allows actors to learn about the technologies' desirability and potentially develop it further (Byrne, 2011). In the case of renewable energy programmes, actors believe that the

technologies provide environmental, economic and social developmental benefits, but need protection against market selection pressures and financial risks involved (Hansen & Nygaard, 2013; van Welie & Romijn, 2017). Protection takes the form of donor funds, investment, and capacity building activities. Such protection is needed due to the generally low-income levels and lack of required skills in remote developing areas (Rolffs et al., 2015).

If niche experiments succeed and are sustained over time, SNM argues that viable niches can be created in which the innovation can survive without continued protection, which can eventually be scaled up to transform or become the regime (Sengers et al., 2016). Three key processes are identified within SNM literature that are important to create and sustain niche experiments, in this research referred to as niche development processes: actor network creation, convergence of expectations, and learning.

Network creation

The creation of actor networks contributes to niche development in three ways. First, it is argued that in order to initiate and link niche experiments, it is vital to create a network consisting of diverse actors with complementary resources (Schot & van Geels, 2008). Second, such networks can sustain development and attract new resources and actors (Kamp & Vanheule, 2015). Third, linkages between the niche experiments enable learning processes and carry expectations, herewith contributing to the two other SNM processes (Coenen et al., 2010). Overall, to enhance the quality of the network, it should be aimed to create a 'broad' network, from international players to local users, who all actively interact and participate in the innovation process (Byrne, 2011; Rolffs et al., 2015).

Convergence of expectations

Convergence of expectations consists of voicing and shaping of expectations, contributing to niche development processes in two primary ways. First, articulating and negotiating of expectations amongst a large number of actors is important to attract attention, new actors, and new resources (Berkhout et al., 2010). Second, convergence of expectations amongst a large number of actors gives direction to niche development, regarding innovation processes, management, and willingness to change. This in turn enhances the quality of expectations (Kamp & Vanheule, 2015). Thus, convergence of expectations means a broad support basis for the new socio-technical practices is created. This enhances sustainability of the niche as well as possibilities for upscaling to influence the regime.

Learning

Learning contributes to niche development in three main ways. First, interactive learning in the niche network facilitates knowledge sharing amongst actors, also aligning expectations (Kamp & Vanheule, 2015). Second, learning by trying amplifies the alignment of technical (technical design and infrastructure) and socio-economic (user preferences, regulation, and cultural meaning) configurations, which is pivotal to successful adoption of renewable energy technologies (Berkhout et al., 2010). Third, learning allows continuous adaptations and improvement of technologies and its embedding in local practices and markets, leading to interactions with the incumbent regime (Berkhout et al., 2010).

This research appreciates that the various terms used within SNM can be confusing and relatively abstract. Table 1 provides an overview of the main concepts, including a short explanation and example.

Table 1. Overview of the main concepts within SNM.

Concept	Definition and example
Experiment	Experimental projects are the first step towards the development of a niche. The real-life experiment focuses on an innovation that is new and radical, with the aim of (1) learning about the desirability of the new technologies and (2) enhancing the rate of application of the new technologies (Kemp et al. 1998; Mourik & Raven, 2006). *For example:* a project that experiments with various solar home system technologies and related business models in several communities on the island of Sumba
Niche	Multiple tightly coupled experiments in protected spaces that constitute a relatively small geographical area. It is aimed to change the current or create a new socio-technical system by initiating co-evolution of the technologies and the market (Kemp et al., 1998). *For example*: Several projects that experiment with various renewable energy technologies (solar systems, micro-hydro power, domestic biogas installations) and business models across the island of Sumba, to create a renewable energy market.
Strategic niche management	Orchestrating the interaction between multiple experiments, to improve the niche's efficiency in achieving its objectives. Ultimately, it is aimed to create a viable and sustainable niche that is able to influence the regime (Mourik & Raven, 2006; Wieczorek, 2018). *For example*: Deliberately managing interactions between the various renewable energy technology experiments in the forms of building capacities and stimulating knowledge exchange. To ensure a viable market for renewable energy is created that can influence or replace the dominant fossil regime in Sumba and the rest of Indonesia.
Renewable energy transition	Changes from a current fossil energy system to a renewable energy system or building up a renewable energy system where energy services were previously absent (Byrne, 2011; Geels & Schot, 2007).

2.3. Applicability to developing contexts: adding the concept of market creation

As the SNM approach has been developed in highly-industrialised countries, various authors argue that the specific socio-economic, political and historical contexts present in developing countries require different approaches to analysis, management and support of transitions (Hansen et al., 2018; Pedersen et al., 2017; Romijn et al., 2010; Wieczorek, 2018). In particular, previous empirical case studies point to the importance of adding the concept of market creation to the SNM framework to improve its analytical power.

Martinot et al. (2002) conduct a large-scale analysis of renewable energy projects implemented in developing countries since the 1970s, showcasing how programmes increasingly take a market-based approach. The authors generalise that there is a need to create new replicable business models to upscale single energy projects. Not only must supply of renewable energy technologies be matched with local demand, this demand often needs to be created in remote developing areas. SNM assumes that experimentation with technologies will automatically evolve into a market niche. However, in developing countries financial assets and existing infrastructure are often lacking, requiring specific focus on the creation of market structures and demand for the technologies (Kamp & Vanheule, 2015).

Various authors further emphasise this point. Comparing renewable energy niche development in Kenya and Tanzania, it was found that market creation is imperative for successful niche growth, primarily related to the provision of maintenance services for technologies (Byrne, 2011). Moreover, Kamp and Vanheule (2015) argue that appropriate business models and marketing methods are crucial for niche development, drawing upon the experiences of wind turbine programme in Kenya. Similarly, Rehman et al. (2010) apply the SNM to renewable energy niche experiments in India and find that the framework overlooks the importance of the creation of local level business networks. Networks should include service providers and retailers that have sufficient technical and management skills, to ensure sustainability of the renewable energy technologies and business models.

Whilst market creation is deemed crucial for niche development processes, the development of a market is also important to address poverty reduction and development goals (Tigabu et al., 2017). Successful businesses can empower and generate income for local communities (Guerreiro & Botetzagias, 2018). However, Byrne (2011) points out that market-based approaches reduce inclusivity, where photovoltaic (PV) installations are not reaching the poorest households. To further explore issues of participation, this paper turns to the field of development studies, capitalising upon its extensive knowledge on community engagement and poverty reduction.

2.4. Learning-based participative approaches to development

Besides the importance of market creation, various studies have found several transformative processes and pathways of sustainability transitions specific to developing countries (Hansen et al., 2018; Wieczorek, 2018). One of the foremost conditions is that niche experiments are often embedded in global flows of knowledge, technology, networks, and resources. A large body of research finds that donors and NGOs are often the ones who play

the largest role in stimulating energy transitions, which is also the case for Sumba Iconic Island (Berkhout et al., 2010; Hansen et al., 2018; Marquardt et al., 2016; Sixt et al., 2017).

Consequently, bottom-up oriented approaches developed with a basis in developing countries could provide valuable insights (Wieczorek, 2018). The field of development studies has most experience in researching the opportunities and challenges for development projects, in this case mostly related to rural electrification efforts. More than two decades ago, Barnes and Floor (1996) already argued that the key aspects to make rural electrification efforts successful are the promotion of local participation and matching electricity services with the needs of beneficiaries. These factors are most likely to be met when ensuring local ownership over the projects. Besides, local ownership is found to bring greater community benefit and development. This removes the classical dichotomy between 'givers' (donors or governments) and 'takers' (consumers), which has led many projects to fail as people do not feel responsible for the introduced technologies (Guerreiro & Botetzagias, 2018).

The importance of local ownership is also reflected in the work of Sovacool (2013), who analyses 10 renewable energy access projects in the Asian context. The author finds 10 common factors that correlate with sustainable programme outcomes (Table 2). Successful projects stimulate community participation, effectively integrating local feedback. The importance of focusing on marketing and promotion is emphasised, to ensure inclusive awareness of the technologies. Moreover, energy services should be coupled with income generation and employment. The latter can ensure after sales services and maintenance are provided, for which building the capacity of local institutions is crucial.

Table 2. Ten common factors that correlate with successful energy access projects in Asia (Sovacool, 2013).

The 10 common factors of successful energy access projects in Asia
1. Technologies meet local needs
2. Flexibility in programme implementation
3. Awareness creation amongst local population
4. Encouraging active participation and feedback from users
5. Requiring community contributions to use technologies
6. Ensuring reliable system operations in the form of installation and maintenance services
7. Providing access to finance
8. Creating income-generating activities
9. Project alignment with national policies
10. Building capacity and investing in local institutions

Going beyond single energy projects, authors who focus on transition programmes in developing countries also emphasise the importance of community engagement. For example, Sixt et al. (2017) reveal how foreign donors aspired to realise a transition to sustainable water harvesting techniques in Jordan but promoted technologies that were too expensive and advanced. Whilst low-cost technologies were locally available, feedback from communities was not taken into account and learning processes were lacking. Moreover, it was found that renewable energy niche experiments in Morocco and the Philippines quickly

failed due to a lack of local capacity, participation and awareness creation (Marquardt et al., 2016). The case of an urban sanitation effort in Kenya further shows that niche development often fails when successful engagement with local frontrunners who can sustain niches is absent (van Welie & Romijn, 2018).

The studies indicate the importance of incorporating development studies with transition theories to assess local societal embedding of renewable energy niches in remote developing contexts. When used on their own, development studies have been critiqued for not having enough of a system view to analyse renewable energy programmes. Yet, the field adds to the SNM framework by providing possibilities to zoom in on localised and communal processes within niche experiments, which are found crucial to sustain niche experiments. In particular, learning-based approaches are considered to be well-suited. Learning-based approaches add to the SNM approach by analysing how local problem-solving capacities can be improved, which is found essential to projects' lasting self-reliance and self-sufficiency once support is withdrawn (Drinkwaard et al., 2010; Ortiz et al., 2012).

The use of learning-based approaches to development project implementation has become popular since the early 1980s, as a response to often disappointed experiences with top-down approaches. A central focus lies on experimentation, adaptation, and a flexible managerial approach to allow organic development of projects (Romijn et al., 2010). Intended beneficiaries are seen as key actors in their own rights, who shape development (Ortiz et al., 2012).

To conceptualise learning-based and participative approaches to development, this research draws on the work of Romijn et al. (2010) and Ortiz et al. (2012). Both authors applied learning-based and participative approaches to renewable energy projects. Following Romijn et al. (2010), the contributions of Korten (1980), Uphoff et al. (1998) and Douthwaite (2002) to learning-based approaches can be considered complementary in creating an analytical framework. Combining their work, the main processes that contribute to successful programme outcomes consist of design and management that fits with the locality, strong local leadership, participation and empowerment, inclusiveness, and local consultation. The stimulation of these processes requires bottom-up capacity building techniques. Ortiz et al. (2012) analyse four renewable energy projects across the world and point out similar components of learning-based and participative strategies that foster self-reliance and self-sufficiency amongst the local population. These include user acceptance and requirement, raising awareness, motivation and identification with the project, supporting local structures for implementation, and providing capacity building to ensure sustainability of projects. Overall, these learning-based participative processes are deemed essential for locally embedding renewable energy niche projects.

2.5. Conceptualisation local societal embedding

This research conceptualises local societal embedding to consist of both SNM niche development processes – including the concept of market creation – and learning-based participative approaches to development. The justification of using the SNM approach - with the process of market creation added - and learning-based participative approaches next to each other has been discussed throughout the chapter. The frameworks complement each other in holistically conceptualising local societal embedding, focusing on environmental (SNM), economic (market creation) and social (learning-based development approaches) sustainability. It provides both a system view on the entire niche as well as being able to analyse community-level processes. In this way, the concept of local societal embedding ensures renewable energy niches are sustainable and have potential for upscaling, as well as that they contribute to poverty-reduction. Table 3 provides an overview of the full operationalisation of the concept of local societal embedding as applied in this research. The table shows how the processes of niche development and learning-based participative processes are further operationalised, with indicators to measure the occurrence of the processes explained underneath.

Table 3. Operationalisation of local societal embedding.

Based on Berkhout et al. (2010), Berkhout et al. (2017), Guerreiro & Botetzagias (2018), Hansen et al. (2018), Kamp and Vanheule (2015), Ortiz et al. (2012), Ramos—Mejía et al. (2018), Romijn et al. (2010), Sovacool (2013), and Wieczorek (2018).

Niche development processes	Learning-based participative processes
1. ACTOR NETWORK CREATION **a. Network composition** heterogeneous group of actors, complementary resources, from all niche experiments and all decision-making levels **b. Interaction and cooperation** High frequency, exchanges of experiences, overcoming power relations **c. Quality of the network** The network enhances resources, knowledge sharing, and contributes to niche development	**1. PROJECT DESIGN & MANAGEMENT** **a. Local resource mobilisation** Building on locally available capabilities and resources **b. Local fit of technologies** Input from local population, addressing local needs, fit with local culture and environment **c. Organisational structure** Fit with innovation and locality **d. Flexibility** Decentralised leadership, ability to change implementation
2. CONVERGENCE OF EXPECTATIONS **a. Voicing of expectations** By actors of all decision-making levels, amongst and within various social groups **b. Shaping of expectations** Negotiation and convergence of expectations, enhanced quality of expectations validated from on-going experiments. **c. Providing direction** For innovation process and management	**2. STRONG LEADERSHIP** **a. Raising awareness** Stimulation adoption and participation local population, influential role in society **b. Communication and monitoring** Lines of communications with beneficiaries, close monitoring project development
3. NICHE-LEVEL LEARNING **a. Learning on technical optimisation** Technical design, maintenance, innovation development co-shaped by various actors **b. Learning on social optimisation** User preferences, overcoming user barriers to adoption, infrastructure dissemination **c. Co-creation of knowledge** Sharing knowledge on technical and social optimisation throughout the network	**3. COMMUNITY-LEVEL LEARNING** **a. Voicing of opinions** Local consultation, information sharing and incorporating feedback from local population, capability local population to share views **b. Capacity building** Training adoption technologies, training management techniques and technical skills
4. MARKET CREATION **a. Creation of appropriate business models** Addressing local population's needs, income-generating, enabling successful market penetration **b. Stimulating local entrepreneurship** Businesses that use energy services, businesses promote and spread new energy services	**4. LOCAL PARTICIPATION** **a. Inclusivity** Accessibility, adoption, and involvement of all community members taking into account local power structures and gender **b. Local ownership** Motivation to adopt innovation, sense of local ownership, sense of responsibility project success

2.6. The role of newly-formed institutional structures

In pursuing the niche development and learning-based participative processes displayed in Table 3, the pivotal role for newly-formed institutional structures can be recognised. Before further explaining their importance, Table 4 explains the definitions used in this research for the concepts of institution and newly-formed institutional structure.

Table 4. Overview of the concepts of institutional structures relevant for this research.

Concept	Definition, explanation, and example
Institution	'Institutions include laws, regulations and policies (formal institutions) as well as social practices, norms and conventions (informal institutions) regarding a particular socio-technical configuration' (Byrne, 2011). *Example*: A cooperative in an institution that is owned and operated by its members to meet a common and specific goal. For example, the cooperative is guided by agreed upon regulations and policies (formal institutions) and conventions (informal institutions) to manage a micro-hydro installation.
Newly-formed institutional structure	'A structure of institutions that are created by multiple (external) stakeholders for a common specific purpose' (author's own, based on explanation below). *Example*: NGOs that create a private service company, that in turn works with local schools to distribute solar home systems. *Explanation:* The concept of newly-formed institutional structures allows for the influence of multiple stakeholders on institutional practices. As renewable energy technologies are transferred from abroad, new institutional configurations are often formed by efforts from both international and local actors (Kebede et al., 2014; Pedersen et al., 2017). Even when existing institutions such as community organisations take on main responsibilities, the institutional structure will inevitably be changed, influenced by a range of stakeholders and in response to practice (Byrne, 2011). Moreover, focus lies on institutional structures to allow for various institutional configurations that cooperate with one common goal for a specific socio-technical configuration.

First, institution building has been discussed as crucial for niche development in developing countries (Ramos-Mejía et al., 2018). Local institutions contribute to niche development by spreading lessons learned between experiments, allowing effective collaboration within networks, and starting new business models. Wieczorek (2018) argues how local institutions can be the potential leaders of sustainability transitions, with various studies discussing how civil society organisations (CSOs) (Slingerland & Schut, 2014), external non-profit intermediaries (Opazo, 2014), and community organisations (Minh et al., 2014; Mohamad et al., 2012) have vital roles in communicating knowledge between niche experiments. This is often related to their local knowledge and contacts (Campel & Sallis, 2013). Herewith, local and regional actors have important roles in establishing effective collaborations and networks that stimulate sustainability transitions (Späth & Rohracher, 2012). Moreover, involving existing and forming new local institutions is found essential to create appropriate business

models that address local needs and create demand for renewable energy technologies (Wieczorek, 2018). Overall, various authors find that the development and diffusion of new institutions is crucial to structure and sustain niche practices (Byrne, 2011; Fuenfschilling & Truffer, 2014; Pedersen et al., 2017).

Second, literature points to the important role that newly-formed institutional structures play in enhancing community-level learning and participation of renewable energy experiments (Eswarlal et al., 2014). Booth (2011) conducts an extensive literature review on the relation between aid and institutions and concludes that it is crucial that donors and NGOs allow space for the construction of institutions that are based on localised problem-solving. This is of utmost importance for the provision of installation and maintenance services for renewable energy technologies, as well as proper social configurations (Ortiz et al., 2012). Moreover, off-grid renewables will not address development and raise living standards unless it empowers and generates income for the community (Guerreiro & Botetzagias, 2018). New institutions can ensure inclusivity, enhance feeling of ownership, empower local actors, and reconfigure power balances (Ramos—Mejía et al., 2018). The latter is especially relevant, as sustainability experiments in developing countries have found to be prone to reproducing ill-functioning institutions that continue to benefit a small privileged group instead of ensuring inclusivity (Oyake-Ombis et al., 2015). Romijn et al. (2010) show how power differences and traditional status can impede effective local participation and feelings of ownership amongst the poor, which endangers longer-term sustainability of interventions. Overall, Booth (2011) argues that external actors should facilitate context-sensitive institutional change to be effective in embedding interventions.

Thus, prior research is indicative of the pivotal role of newly-formed institutional structures in locally embedding renewable energy niche experiments, both contributing to niche development and learning-based participative processes. However, Romijn et al. (2010) argue that research is needed that conducts a more fine-grained analysis of the role local institutions play in creating and sustaining renewable energy niches. Similarly, Hansen et al. (2018) argue that institutional development in transition programmes should further be analysed and Ramos—Mejía et al. (2018) call for research that highlights the nuances that different institutional settings exhibit. Booth (2011) further emphasises that the specific forms that institutions should take to successfully contribute to development programmes is still undefined. Although the author recognises context dependency, he calls upon researchers to deliver more finely tuned ideas about what the building blocks are for facilitating appropriate and feasible institutional innovations. This research addresses these knowledge gaps by evaluating how various newly-formed institutional structures contribute to local societal embedding as conceptualised in Table 3.

2.7. The conceptual model

Figure 3 presents the conceptual model of local societal embeddedness and the role of newly-formed institutional structures, based on the theoretical embedding presented in this chapter. Newly-formed institutional structures are hypothesised to contribute to inter-experiment niche development processes as well as intra-experiment learning-based participative processes, and herewith to local societal embedding of the renewable energy niche. This research applies the conceptual model to the case of the renewable energy niche created under the SII programme in Indonesia, analysing the roles of three newly-formed institutional structures: a cooperative, social enterprise, and private service company.

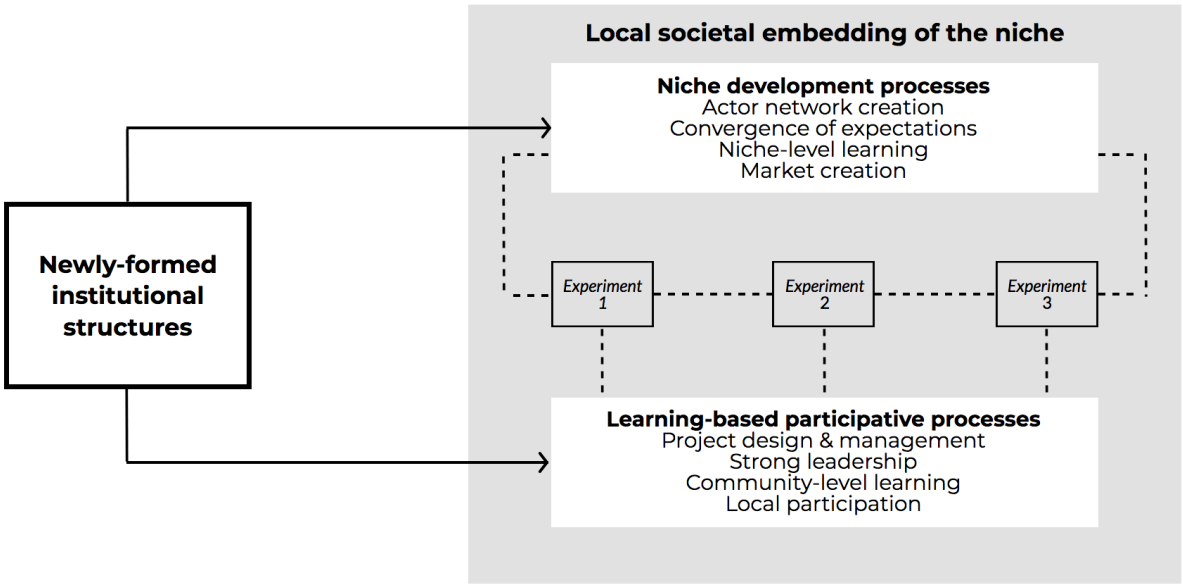

Figure 3. The conceptual model.

Chapter 3: Research design

This chapter first discusses the research objectives and questions that arise from the theoretical embedding and conceptual model. The analytical steps to answer the research questions are explained in the research framework. Subsequently, an overview of the study area is provided. This is followed by explanations of the data collection and data analysis methods. Finally, this chapter reflects on ethical considerations and potential limitations of the deployed methods.

3.1. Research objectives and questions

The central research question is:

How can newly-formed institutional structures contribute to local societal embedding of renewable energy niche experiments in remote developing contexts?

First, qualitative research is conducted on the case study of the Sumba Iconic Island (SII) programme to reach the first two objectives. The first objective is of explorative nature and examines how newly-formed institutional structures emerge in renewable energy niche experiments using documentation on the SII programme and key informant interviews. The following explorative sub-question is answered in chapter 4:

SQ1: Which newly-formed institutional structures can be recognised within the niche?

The second objective is to analyse which role newly-formed institutional structures play in enhancing local societal embedding of the renewable energy niche, by examining their contribution to both niche development processes and learning-based participative processes. The two results chapters are structured according to the following two sub-questions:

SQ2: How do the newly-formed institutional structures contribute to renewable energy niche development processes?

SQ3: How do the newly-formed institutional structures contribute to learning-based participative processes of renewable energy experiments?

Based on the results chapters, a synthesis of the contributions of the newly-formed institutional structures to local societal embedding of the renewable energy niche is provided. Findings are embedded in existing literature. The following sub-question is herewith answered in the discussion chapter:

SQ4: What are challenges and opportunities for newly-formed institutional structures to contribute to local societal embedding of the renewable energy niche?

The third objective transcends the study area and is to provide both practical and theoretical recommendations. Practical recommendations are given in the discussion chapter regarding

effective institutional building blocks that contribute to local societal embedding of renewable energy niche experiments. The conclusion chapter further provides theoretical recommendations that aim to advance the use of transition theories in developing contexts.

3.2. Methodology

This research employs an exploratory case-study approach that is predominantly qualitative, complemented with secondary quantitative data and comparison to literature. An exploratory case-study is deemed appropriate given the before-mentioned lack of empirical data on renewable energy transitions in remote developing contexts (Guerreiro & Botetzagias, 2018). To analyse the differentiated roles of various newly-formed institutional structures, a comparative case study analysis using information-rich data is needed (Byrne, 2011; Pedersen et al., 2017). Therefore, this research focuses on three experiments and accompanied newly-formed institutional structures within the SII niche.

Considering the complexity of the SNM processes, the non-numerical nature of the conceptual model and the explorative nature of the research, it is argued that gathering qualitative information is most appropriate (Caniëls & Romijn, 2008). Yet, it is a common method in transition study analysis in developing countries to complement qualitative research with secondary quantitative data (Sixt et al., 2017). To further increase the credibility and validity of the results, triangulation of methods and sources is applied, including semi-structured interviews, focus group discussions (FGDs), field observations, and secondary research and reports (Verschuren & Doorewaard, 2010).

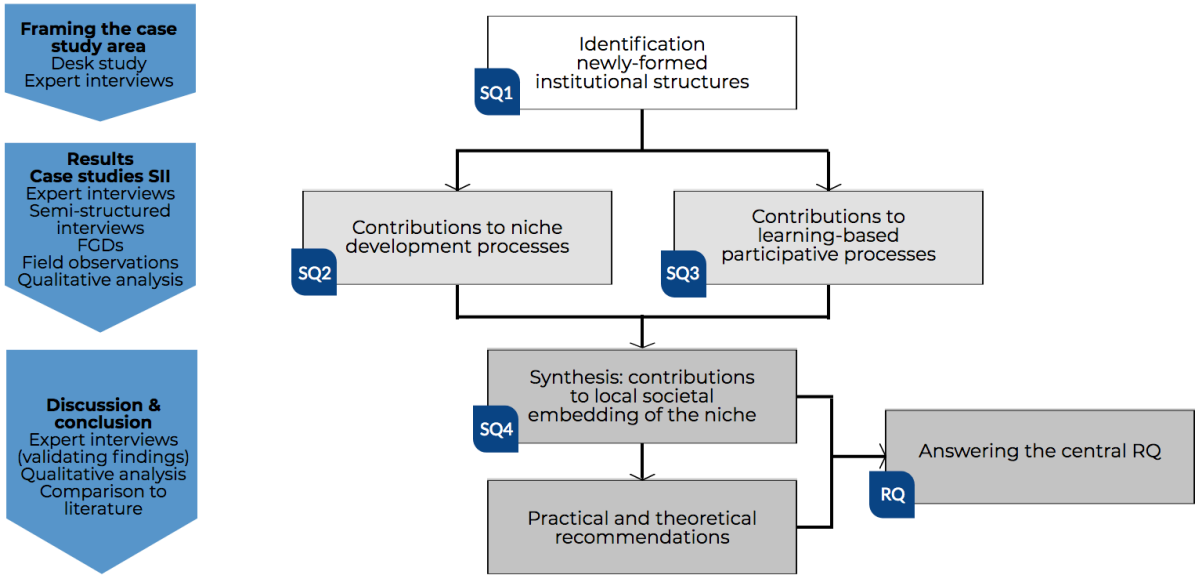

Figure 4. The research framework.

Figure 4 presents the research framework. It is structured according to the research questions and follows three main analytical steps, with the appropriate research methods displayed in the blue arrows. First, the case study area of Sumba is introduced and various

newly-formed institutional structures are identified, as are discussed in the next chapter. Second, field research was carried out for two months in Indonesia collecting qualitative data to analyse how the newly-formed institutional structures contribute to niche development processes on the one hand and learning-based participative approaches on the other, the results of which are presented in chapter 5 and 6. Subsequently, the discussion chapter compares the results of this research to findings in literature. Herewith, practical and theoretical recommendations can be made.

It must be mentioned that although the research strategy consists of sequential phases on paper, in reality a process of continuous comparison of findings with previous found phenomena and notions in existing literature was applied and data analysis was conducted in circular manners, to ensure relevance and accuracy of findings (Verschuren & Doorewaard, 2010). Before further elaborating on the data collection and analysis methods used, an overview of the case study area will be presented.

3.3. Study area

To test and illustrate the merits of the conceptual model, the multi-actor SII programme in Indonesia is used as a case study area. Not only does the impoverished island of Sumba serve as an ultimate reflection of a remote developing context (it takes a one-hour flight across the ocean to reach the closest city), it also hosts a unique multi-actor renewable energy programme. Before touching upon the programme, a short introduction and justification of the relevance of the Indonesian context is provided.

Indonesia

As the world's largest archipelago, Indonesia faces great challenges in improving energy access due to growing energy demand, persistent problems of energy poverty, and climate concerns (Chelminski, 2015). Indonesia is representative of the challenges that many other Asian countries are facing: whilst on the one hand population growth, a booming economy and increased industrialisation increase energy demands and put pressure on the existing grid, impoverished people in remote areas live without electricity (Guerreiro & Botetzagias, 2018). Approximately 42% of the population, over 100 million people, fall within the energy poverty category, and Indonesia's electrification rate of 83% falls behind other countries in the region (PwC, 2013). The Indonesian government has aimed to improve energy access, for which grid extension has received most attention. This is problematic, as energy access is most limited on Indonesia's poor eastern islands (with electrification rates below 40%), where grid connections are too expensive due to geographical and demographic remoteness.

Although Indonesia has a highly diverse territory spread over 17,000 islands with different physical and climate conditions, a common factor is the country's vast potential for renewables, including solar, wind, hydro and geothermal. In 2012, only a fraction of this potential had been tapped, with renewable energy accounting for 6% of Indonesia's energy supply (Damuri & Atje, 2012). As a result, off-grid renewable energy approaches to rural electrification have been pointed out as the way forward (Ardiansyah et al., 2012; Gunningham, 2013). (Inter)national development agencies play an important role in demonstrating the potential of off-grid renewable energy technologies on Indonesia's remote

islands and have delivered a range of financial and technical assistance, policy advice, trainings and pilot projects (Chelminski, 2015). Yet, most renewable energy projects are small-scaled and lack participatory development and community-based management, as a result of which many tend to fail (Guerreiro & Botetzagias, 2018). An initiative that can be considered unique in both Indonesia as well as the world - due to its long-term and integrative focus, including a variety of (inter)national and local actors and range of technologies -, is the SII programme.

Sumba Iconic Island programme

Initiated in 2014 by international NGO Hivos, various government bodies, investors, NGOs, and CSOs committed themselves under SII to an ambitious target. It is aimed to increase electrification rates from 24.5% in 2014 to 100% in 2023, of which 65% should be sourced from renewables. The programme aspires to showcase renewable energy as a solution for poverty and climate change alleviation in remote developing areas (and especially for other small- and mid-sized islands), and to demonstrate replicable business models for the provision of renewables for policy-makers and development practitioners (Hivos, 2015).

Herewith, the SII programme is deemed highly suitable as a case for this research. First, the SII initiative can be considered a niche creation programme, which ultimately aims to alter the energy landscape in Indonesia and instigate a wider energy transition. Simultaneously, a large focus lies on poverty reduction and capacity building, exposing learning-based participative processes. Moreover, the programme has focused on institution building by working with cooperatives, social enterprises and renewable energy service companies to ensure sustainability and replicability of the programme.

Figure 5. A map of Indonesia with capital Jakarta and the island of Sumba indicated.

Table 5. Background information on Sumba (Hivos, 2015; Langford et al., 2017).

Topography
• Sumba has a land mass of 11,000 km^2, which is just over a quarter of the size of the Netherlands. • Settlement patterns include small villages hosting around 1,000 to 1,500 people, sub-village settlements are often 1-5 kilometre apart, and more disturbed settlement patterns with houses scattered among fields and hills. • The three largest towns are connected by a paved road. The majority of villages are however accessible by unpaved roads, requiring motorbikes or four-wheel drive cars. • Market facilities are limited within villages. A small kiosk often sells snacks, soap, and cigarettes and most sub-districts hold weekly markets. • Most villages have elementary schools, although in poor states (without electricity).
Sumba's population
• Sumba has around 750,000 inhabitants. • Average per capita income was 50% of the national average, and poverty is widespread (with 33% officially being classified as poor). • Around 80% of the population are subsistence farmers, with a cash economy being limited.
Access to electricity
• In 2014, around 25% of the population was connected to the diesel-powered electricity grid. • In 2015, around 70% of the population was dependent on kerosene for lighting and firewood for cooking, with no other access to energy.

Besides the match with the conceptual model, the locality of Sumba enhances the model's relevance and applicability in geographical contexts with particular harsh living conditions (Ulsrud et al., 2015). Located in the eastern province of Indonesia (Figure 5), the island has one of the highest incidences of poverty and the lowest level of access to basic services in the country, being considered as one the most peripheral regions in Indonesia with highly dispersed settlement patterns (see Table 5 for more information) (Lundry, 2009). Herewith, it is one of the most difficult places to implement decentralised renewable energy systems. As argued by Ulsrud et al. (2015), the resulting model and lessons learned are therefore especially relevant for poor, remote villages in both the Asian context and elsewhere, and when successful provide optimistic outlooks for less remote places.

A typical Sumbanese landscape with dispersed settlement patterns.

Although the Indonesian government is officially the head of the steering panel of SII, its contributions are limited. The main renewable energy projects within SII are executed by international NGOs and investors. These projects take a market-based approach, in which users have to pay to use renewable energy products. As mentioned before, the projects have been accompanied by institution building, to ensure installation, maintenance and management responsibilities are put in the hand of locals. This research focuses on three newly-formed institutional structures that can be recognised in the niche, including the local agents they work with. As data collection is based on their structures, Figure 6 provides a short overview including the renewable energy technologies that the institutions provide. Chapter 4 will elaborate on the specific institutional structures.

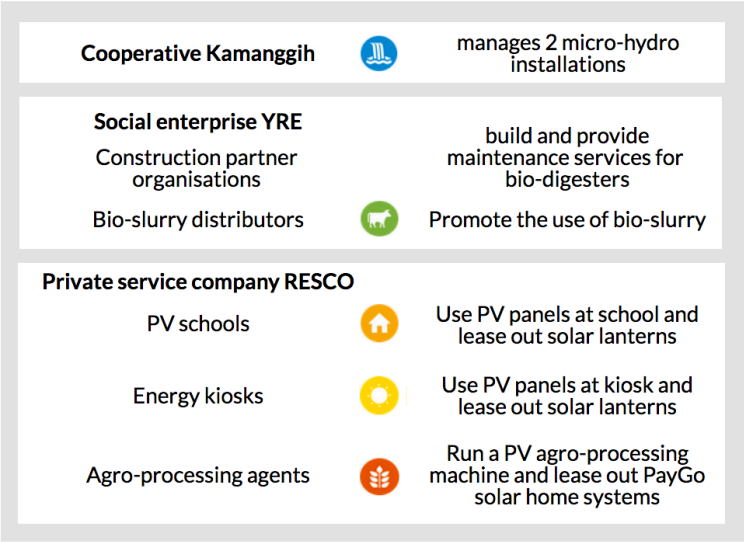

Figure 6. The three newly-formed institutional structures and technologies offered (via local agents).

3.4. Data collection

The data collection was conducted in Indonesia during a two-month fieldwork period between March and May 2018, in which more than 130 respondents took part in interviews and FGDs. Expert stakeholders from the implementing NGOs, an investment company and government were interviewed at the beginning and end of the fieldwork period. First to frame the niche and later to validate findings and recommendations. They were selected based on their position within their organisations, where it was aimed to speak both to high-level management and local field staff. Appendix A provides an overview of the respondents and their functions.

The majority of the time was spent on Sumba, were semi-structured interviews and FGDs were conducted with all relevant stakeholder groups. As argued in previous research (Blum et al., 2015; Pedersen et al., 2017), it is important to identify and interview as many 'strategic groups' as possible, to acquire a complete picture of the niche. Strategic groups were identified during the research and – besides the experts mentioned above - ranged from staff of the institutions researched, influential people in communities such as village leaders, users of technology and non-users. This approach enabled ongoing triangulation and validation of answers (Pedersen et al., 2017).

To accommodate the system view that SNM requires, for each newly-formed institutional structure and accompanied technologies various villages that received the technologies were visited. These were selected based on information from NGO Hivos, for which it was aimed to visit both 'success stories' and communities that are struggling to adopt the technology. By evaluating contrasting project outcomes, it was aimed to give a complete overview of the local societal embedding of the niche. Due to the disturbed settlement patterns in Sumba, also users and non-users living in surrounding hamlets and hillsides were interviewed.

The research area was confined to East Sumba to ensure contextual factors did not influence the ability to compare case study areas. East Sumba was chosen as it is the largest and most sparsely populated district, with an average of 33 people per squared kilometre, which hosts around half of all Sumba's villages (Langford et al., 2017). Herewith, it can be considered a highly 'remote' area. Moreover, this area is considered cultural homogenous, enhancing possibilities to compare various communities who received renewable energy technologies. This resulted in a case study selection as displayed in Figure 7. To ensure that the learning-based participative processes could be researched sufficiently, every case study community was visited for two to four days until saturation of findings was reached.

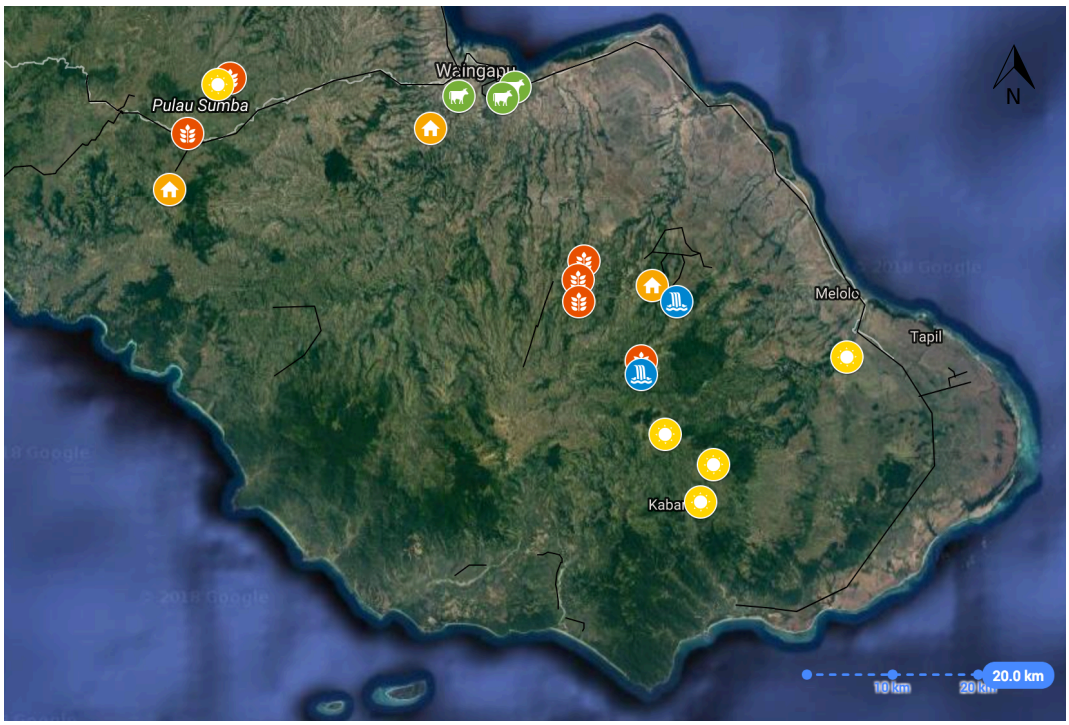

Figure 7. Map of East Sumba with the case study areas.

The black lines show grid connections. Green cow icons indicate bio-slurry distributors, blue waterfall icons micro-hydro installations, red grain icons the agro-processing agents, orange house icons PV schools and yellow sun icons energy kiosks.
To access the interactive map, use the following link: https://goo.gl/criFLv.

In total, 92 interviews have been conducted. The semi-structured nature of the interview gave respondents the opportunity to raise issues outside of the conceptual model, allowing space for inductive theory forming and analysis from the emic perspective (Bruges & Smith, 2009). The question formats can be found in Appendix B. It was designed along the principles of Sixt et al. (2017), to touch upon the overarching themes from the two analytical frameworks, with probing follow-up questions to elicit in-depth responses. The initial question lists were piloted to ensure questions were relevant and easy to understand for respondents. A key element in studying institutional work is focusing on practice, to create data on the awareness, skills and reflexivity of actors (Lawrence et al., 2011). Following Pedersen et al. (2017), stakeholders from the newly-formed institutional structures were therefore asked to describe the ways in which they collaborate with other stakeholders, engage with customers, and interact with the NGOs. For users and non-users, interviews primarily touched upon the learning-based participative processes. Sampling strategies consisted of snowball sampling, taking into account the before-mentioned strategic groups and ensuring household locations across the communities and surrounding areas were covered. Moreover, it was strived for equal gender representation, with gender division being 62 female compared to 70 male amongst the respondents.

Next to the semi-structured interviews, six FGDs were organised to involve a larger number of respondents and trigger discussion on the varying impacts of technology distribution points across localities. Selection criteria of FGD participants consisted of 1) respondents fall

under one strategic groups (e.g. only users or only non-users) 2) respondents are from different localities, with varying distance to distribution points, and 3) it was strived for equal gender representation. During the FGD it was ensured every respondent was able to voice their opinion. The same structure as the interviews (Appendix B) was used.

Table 6 provides an overview of all the interviews and FGDs conducted. To further triangulate findings, continuous field observations and notes, discussions with influential local people, and comparison to project evaluations and reports (for a list of reports used see Appendix C) were carried out.

Table 6. Number and type of respondents, including information on gender and research methods used.

Experts / Newly-formed institutional structure	Number and type of respondent	Gender	Research method
Experts	11 NGO experts	4 female/6 male	Interview
	1 investor	1 male	Interview
	1 Indonesian National Government official	1 male	Interview
Cooperative Kamanggih	3 Cooperative Kamanggih staff: Director Manager, Secretary, and Manager Funds and Loans	1 female/2male	Interview
	2 micro-hydro operators	1 female/1 male	Interview
	11 users micro-hydro	5 female/6 male	Interview
Social enterprise YRE	1 YRE staff: Manager	1 female	Interview
	1 construction partner organisation	1 male	Interview
	3 bio-slurry distributors	2 female/1 male	Interview
	4 users bio-digester	3 female/1 male	Interview
	3 non-users bio-digester	1 female/1 male	Interview
Private service company RESCO	2 RESCO staff: President Director and Manager	2 male	Interview
	12 PV school staff (at 3 schools)	8 female /4 male	Interview & FGD
	14 users lanterns PV schools	9 female/5 male	Interview & FGD
	8 non-users lanterns PV schools	6 female/2 male	Interview
	5 energy kiosk owners (at 5 kiosks)	2 female/3 male	Interview
	13 users lanterns energy kiosks	5 female/8 male	Interview & FGD
	11 non-users lanterns energy kiosks	7 female/4 male	Interview & FGD
	6 agro-processing agents	1 female/5 male	Interview
	17 users agro-processing machine	6 female/11 male	Interview & 2 FGDs
	1 non-user agro-processing machine	1 female	Interview
	4 users PayGo solar home systems	4 male	Interview
	4 non-users PayGo solar home systems	1 female/3 male	Interview

3.5. Data analysis

Hennink et al.'s (2010) approach of qualitative data analysis was adopted; the broad principles of grounded theory were used, whilst acknowledging deductive strategies. This method was found appropriate for this research for the following reasons. The conceptual model aims to advance theoretical notions of SNM and learning-based development approaches, and hence the two models were utilised as guidelines to ensure relevance for theoretical contributions. However, due to the explorative nature of the research it is necessary to provide room for important dynamics arising from the data. Hence, this research allows for inductive theory-building.

Data analysis attempted to be systematic, to enhance credibility and auditability (Noble & Smith, 2015). Extensive notes were taken during interviews, field observations and FGDs, often supplemented with recordings. Subsequently, notes and recordings were transcribed to ensure conclusions are formed that are well rooted in the data (Hennink et al., 2010). The transcripts, notes and documents were analysed using theoretically informed coding schemes subjected to qualitative thematic analyses (Braun & Clarke, 2006). Herewith, data were coded for pre-established codes relating to the conceptual model as well as for emerging patterns (Pedersen et al., 2017). Analysis was carried out in Nvivo software to enhance consistency and analytical transparency and was of iterative character. The latter allowed for the consideration of rivalry explanations and examine evidence from multiple perspectives (Yin, 2009). As a result, the conceptual model was refined and codes emerging from the data were added throughout the research period until all relevant concepts were included (see Appendix D for the codebook).

Once theory is developed, it is important to verify that it is well-grounded and supported by the data. This research used real-life validity methods as suggested by Hennink et al. (2010). Interpretations of the data were discussed with expert stakeholders from the implementing NGOs. This resulted in refinement of the emerging theory, strengthening validity of the final recommendations. Moreover, to be able to generalise findings, case study data was compared to literature.

3.6. Potential limitations and considerations

Inherent to all research, the methodology is not without its limitations. As the research is based almost entirely on qualitative data, analysis is intrinsically based on interpretation. This research attempted to be systematic and transparent in data collection, analysis and discussion to ensure an appropriate weight can be given to the conclusions (Byrne, 2011). It is aimed to represent the situation as truthful as possible, ensuring that an objective overview of the findings is created.

The positionality of the researcher as well as those of respondents can form a limitation to data collection. In the first week, staff from NGO Hivos accompanied the researcher to introduce the projects and involved communities. Although the researcher's impartiality was stressed before, during and after interviews, the presence of Hivos' staff this will inevitably have led to respondents giving socially desirable answers. To overcome this issue, an independent research assistant was hired for the remainder of the time. Nevertheless, respondents often felt they had to express their gratitude for receiving renewable energy

technologies. Simultaneously, it was realised that Sumba's cultural habits often impede especially women and poorer households to voice their opinions. To elicit more critical and truthful answers, the goal of the research was explained to enhance understanding of why certain questions were asked. Moreover, ethical considerations were taken into account. All respondents were informed that all research records will be kept confidential and are anonymised. They were offered to stop at any point throughout the interview. The researcher also tried to create a trusting atmosphere, for which the use of a local translator was very beneficial.

At the same time however, it should be recognised that using a translator might lead to some losses in data. Most rural Sumbanese households only speak in their own dialect, which differs substantially from the national language Bahasa Indonesia. As a result, in certain cases the researcher had to work with two translators, the hired translator and a community member who spoke the local dialect. When in doubt the respondents fully understood questions or translations were sufficient, the researcher took the time to ensure losses in data were minimised.

Furthermore, interviews can be a source of bias, especially in the case of expert interviews. When respondents are highly involved in the programme, they may be determined to give a partial view on the topic. As argued by Byrne (2011) however, this is not an entirely problematic issue when it comes to analysing SNM. The concept 'convergence of expectations' tries to capture rhetoric, which respondents may reveal when providing a partial view. To assess the plausibility of the given views, this research triangulated when possible by comparing views to other available evidence on the topic.

It should further be noted that the experiments under SII have been implemented with varying time frames, between 3 years to 6 months. Hence, not all impacts will have materialised yet. Nevertheless, this research aims to examine initial insights into the impacts of newly-formed institutional structures, in order to provide recommendations to further promote sustainable and successful outcomes of the interventions within SII and beyond. By embedding case study findings extensively in literature, generalisability and theoretical relevance is enhanced.

Chapter 4: Identification newly-formed institutional structures

Before discussing the results, this chapter addresses the first explorative sub-question: *Which newly-formed institutional structures can be recognised within the niche?* Table 7 provides an overview of the newly-formed institutional structures, and the accompanied renewable energy projects and other organisations involved in their implementation. First-level institutions refer to the institutions that have a management function, which are cooperative Kamanggih, social enterprise YRE and private service company RESCO. The latter two have a regional function, working with local agents that install and/or distribute the renewable energy technologies. These local agents are referred to as second-level institutions.

Table 7. An overview of the newly-formed institutional structures and accompanied renewable energy technologies implemented within SII by February 2018 (based on CIRCLE Indonesia, 2018).

Newly-formed institutional structures		**Renewable energy project**	**Implementing organisations**
1st-level	***2nd-level***		
Cooperative **Kamanggih**		2 micro-hydro generators were built that sell electricity to surrounding communities	NGO Hivos NGO IBEKA State electricity company PLN
Social enterprise **YRE**	*Construction Partner Organisations*	550 domestic bio-digesters installed at households across Sumba	NGO Hivos
	Bio-slurry distributors	Promoting the use of bio-slurry as organic fertiliser	
Private service company **RESCO**	*PV schools*	24 solar PV systems with charging stations for lanterns at schools across Sumba 4,500 lanterns leased out to households	NGO Hivos NGO Winrock International
	Energy kiosks	30 solar PV systems with charging stations for lanterns at kiosks across Sumba 3,500 lanterns leased out to households	NGO Hivos NGO Winrock International
	Agro-processing agents	22 solar-powered agro-processing mills across Sumba 2,700 PayGo solar home systems leased out to households	NGO Hivos Investor Village Infrastructure Angels

4.1. Cooperative Kamanggih

Cooperative Kamanggih was established in 1999 by Indonesian NGO IBEKA to manage their development projects for clean water in Kamanggih village. Today, the cooperative is involved in SII. They are responsible for the management of two micro-hydro facilities and work as a construction partner organisation for social enterprise YRE. The micro-hydro facilities were built in 2011 and 2017 using funding from NGOs Hivos and IBEKA. They both produce around 65 kWh of electricity per day, serving surrounding communities with electricity.

One of the micro-hydro installations.

The cooperative operates independently with seven local staff members which have primarily been trained by NGO IBEKA. The main income source of the cooperative is selling electricity from one micro-hydro installation to the state electricity company PLN, as it is connected to the central grid. The second micro-hydro is connected to a mini-grid, and households pay directly to the cooperative. The cooperative further receives income from the saving and loan scheme they run for local community members. For starting new projects, NGO IBEKA primarily contributes to funding. Furthermore, the cooperative attempts to access international funding with the help of NGOs IBEKA and Hivos.

4.2. Social enterprise YRE

YRE is a Sumbanese social enterprise, founded by NGO Hivos in 2010 as part of a previous biogas programme. They have six Sumbanese employees and a manager from another Indonesian island. YRE is one of the three consortium members of SII (next to NGO Hivos and investor company Village Infrastructure Angels), in which it is responsible for the bio-digester programme and developing a bio-slurry market. The domestic bio-digesters have a volume between four and six squared metres, which require households to collect the dung of two to three pigs to produce enough gas to use for cooking. Bio-slurry can be produced

from the residual product, which is used as organic fertiliser. Using funding from the SII programme, YRE subsidises 70% of the costs of building a bio-digester. YRE staff have been closely trained and supported by NGO Hivos but are now operating independently. It aims to secure its own funding sources from international donors and companies that provide corporate social responsibility funding.

Construction partner organisations

Construction partner organisations are parties contracted by YRE that are responsible for conducting pre-construction assessments, building the bio-digesters, giving usage instruction, and providing post-construction maintenance services. Construction partner organisation consist of existing CSOs, credit unions, cooperatives, farmer groups, and individuals. The construction partner organisations are responsible for promoting bio-digesters, and they receive 800,000 IDR (48 euro) per bio-digester built.

The construction partner organisation building a domestic bio-digester.

Bio-slurry distributors

Bio-slurry distributors are bio-digester users who have been trained by YRE on how to make bio-slurry, use it as organic fertiliser, and sell it to other farmers with the aim of creating a bio-slurry market on Sumba. Bio-slurry distributors were selected based on their business sense and influential position in society, including kiosk owners, head of farmer groups, and seed distributors.

4.3. Private service company RESCO

RESCO was founded in 2016 by NGOs Hivos and Winrock International and supported by the investor company Village Infrastructure Angels as part of an American funding programme (MCA-I). To safeguard the sustainability of renewable energy interventions, the

NGOs believed a local private service company needed to be established that can provide maintenance services. RESCO has five local Sumbanese technical staff members and two Indonesian managers. The technicians received on-the-job training from the international NGOs and are responsible for installing PV installations across Sumba. To distribute technologies, RESCO works with PV schools, energy kiosks, and agro-processing agents. RESCO is responsible for managing the business models, including fee collection and provision of maintenance activities.

RESCO's income consists of the electricity fees paid by users of the lanterns, agro-processing services, and PayGo systems. The lanterns were funded as part of the American fund, and hence RESCO can keep all profits. The agro-processing mills and PayGo systems were funded using a loan from Village Infrastructure Angels, and income is partly used to pay back the loan. RESCO is designed as a private entity, to open up possibilities to work with investors. Currently, RESCO is trying to find new clients and investors to enhance quality of their services and expand off-grid connections on Sumba.

PV schools

The first distribution channel RESCO work with are PV schools. In total, 24 elementary schools without access to electricity were selected by the international NGOs. The schools pay a monthly fee of 300,000 Indonesian Rupiah (IDR) to use electricity from a PV system (solar panels and a battery) installed by RESCO. Besides, the PV system is used to charge around 100 lanterns that are leased out to students. The lanterns are shock- and water-proof and portable but can also be attached to the ceiling to light an entire room. They can only be charged in a special charging board present at the school. Families pay an initial 50,000 IDR (3 euro) membership fee. For each charging they pay 1,500 IDR (9 eurocents). All revenues from the lantern business go to RESCO. RESCO is responsible for repairing or replacing broken lanterns. After 300 times charging, users own the lanterns and the warranty expires.

A PV school.

The charging board for the lanterns.

Energy kiosks

Energy kiosks are the second distribution channels RESCO works with. Existing kiosk owners, often selling daily necessities such as snacks, toiletries and cigarettes, were selected by the NGOs because of their prevailing business mind-set. Energy kiosks receive a PV system, a few light bulbs and a television to use in the kiosk, and lanterns to lease out to households (for the same prices as at the PV schools). RESCO has varying agreements with kiosk owners. Some pay a monthly fee of 200,000 IDR (12 euro) and share profits from the lantern business with RESCO. Others do not pay a monthly fee, but RESCO receives all revenues from the lantern business.

An energy kiosk.

Agro-processing agents

The third distribution channel RESCO works with are agro-processing agents. Agro-processing agents are often local farmers. They receive a PV system, three lights to use in their house, and an PV agro-processing machine for free by RESCO. Community members can process corn at the agent. Per kg of corn processed, customers either pay 500 IDR (3 eurocents) or 0.2 kg of corn. RESCO receives 50% of the price, being 250 IDR (1.5 eurocent) per kg corn processed. The agent is responsible for selling the corn when customers pay in corn. As the milling service is not very profitable for either the agent or RESCO, the agents also lease out PayGo solar home systems (a PV panel with a battery, three lamps and a mobile phone charger). The system cannot be used for any other electricity needs. Customers can install the PayGo systems at their houses, paying 50,000 IDR (3 euro) per month. They have to buy a monthly code at the agro-processing agent, otherwise the system switches off. RESCO provides a guarantee on the PayGo systems for three years, after which the ownership is transferred to the user. The agro-processing agent and RESCO both receive 10% of every code sold. The remainder is used to pay off the loan from investor Village Infrastructure Angels.

A solar home system. A small PV pane (see cover photo) lies on the roof, the battery is shown on the right and one of the three lamps lighting up the house on the left.

The PV agro-processing machines. The red machine is a corn sheller and the grey one grinds the corn into flower.

An agro-processing agent and his family in front of their house where they run they agro-processing business.

Chapter 5: Results Niche Development

This chapter discusses the results regarding sub-question 2: *How do the newly-formed institutional structures contribute to renewable energy niche development processes?* Niche development processes are analysed using the adjusted strategic niche management framework (see Table 8) as discussed in Chapter 2, according to which the results in this chapter are structured. It is examined how each of the newly-formed institutional structures – cooperative Kamanggih, social enterprise YRE and private service company RESCO – contribute to the niche development processes, of which a concise overview is given at the end of the chapter.

Table 8. The niche development processes.

Niche development processes
Actor network creation
Network composition
Interaction and cooperation between actors
Quality of the network
Convergence of expectations
Voicing of expectations
Shaping of expectations
Providing direction for innovation processes
Niche-level learning
Learning on technical optimisation
Learning on social optimisation
Co-creation of knowledge
Market creation
Creation of appropriate business models
Stimulating local entrepreneurship

5.1. Actor network creation

5.1.1. Network composition

Figure 8 shows the key stakeholders and their interactions within the SII niche. The network consists of a heterogenous group of actors. A key informant from NGO IBEKA (who founded the cooperative) explains the importance of having a broad actor network to instigate renewable energy transitions:

> *'Technically there are so many big opportunities for renewable energy on Sumba: for PV, wind, water, biogas. But the main problem is that the cost of instalment is very high, and there is no money in the local economy. It needs the collaboration of many parties: the government, private investors and businesses, NGOs. They all have to work together.'*

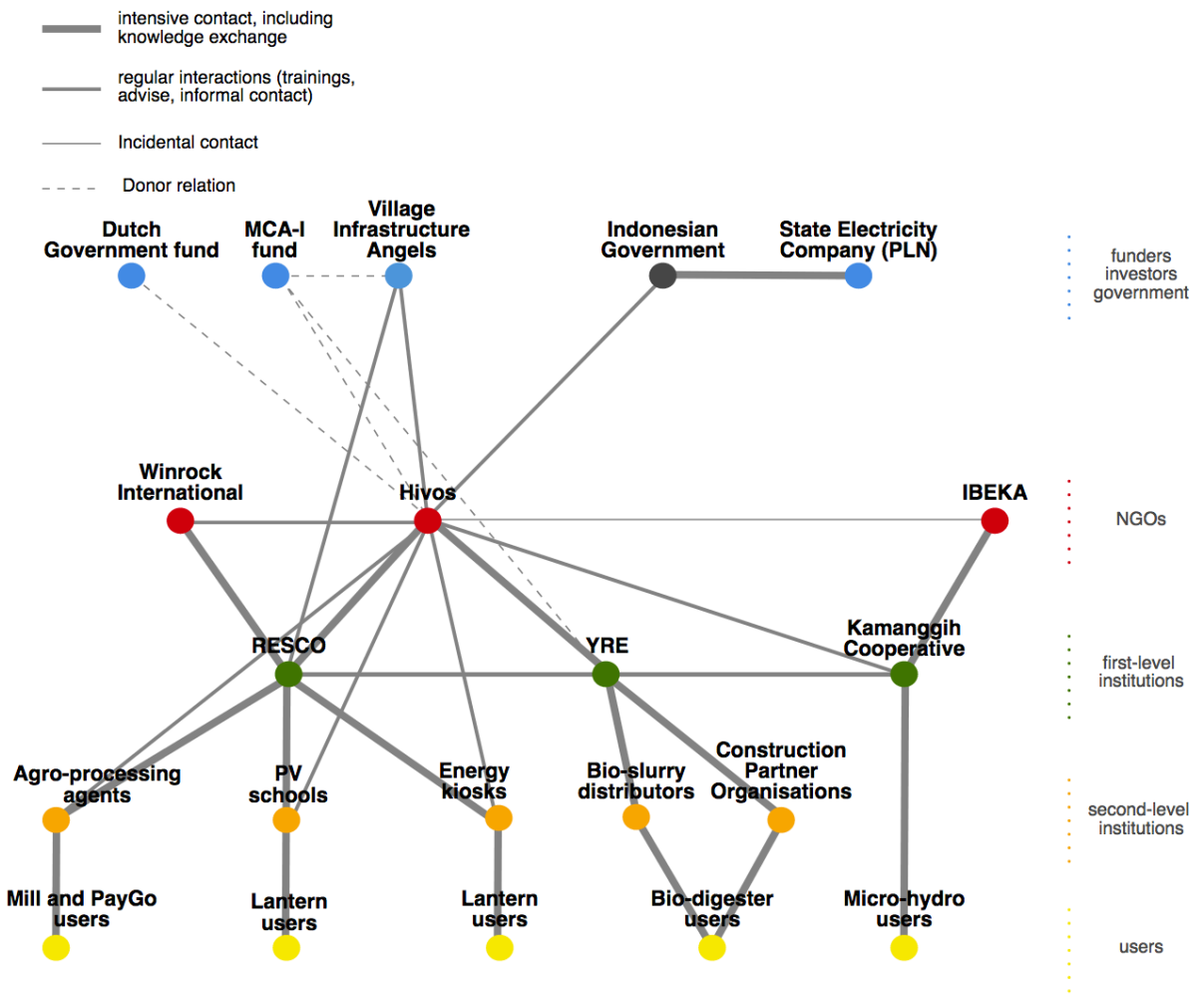

Figure 8. Key stakeholders and their interactions within the SII niche.

Figure 8 demonstrates how the various NGOs and donors work together with newly-formed institutional structures to implement renewable energy projects. The first-level institutions – cooperative Kamanggih social enterprise YRE and private service company RESCO – directly interact with a variety of NGOs. They were created by the NGOs and perform management functions as described in the previous chapter. Furthermore, private service company RESCO and social enterprise YRE are active throughout Sumba, and hence fulfil a regional function. To distribute the technologies in the remote communities across the niche, they work with second-level institutions. The second-level institutions thus form a bridge to the local population. The next sub-chapter further discusses the level of interaction between actors within the niche network, as a depicted by the lines in Figure 8.

5.1.2. Interaction and cooperation between actors

Cooperation amongst official SII stakeholders

Every six months, a coordination meeting is organised for all official SII stakeholders, including government bodies, the NGOs, and investors active in the network. Although useful for setting direction, respondents indicate that cooperation and streamlining of projects with the government is often difficult. This can be partly explained by the complex, and often

indicated as bureaucratic, structure of governance, with various different ministries and levels of governments involved in providing renewable energy technologies.

As the initiator of the SII programme, the central position of NGO Hivos can clearly be observed in the network, maintaining close contact with investors, donors, NGOs, and the newly-formed institutions. Direct interaction between the other NGOs and investor is limited. As explained by the manager of NGO IBEKA: '*we all try to focus on our own speciality'*. This indicates the solitary approaches NGOs tend to take.

Cooperation between NGOs and newly-formed institutions
Cooperation is primarily observed between the implementing NGOs and the newly-formed institutions. Cooperative Kamanggih maintains a close relationship with NGO IBEKA, whose field office is located in the community since 1999. The NGO has provided more than 10 years of capacity building efforts before the cooperative was able to operate independently. Moreover, having an involved NGO in close proximity eases funding requests for the cooperative, as NGO IBEKA is able to grasp local challenges and opportunities. For example, after the success of the first micro-hydro, funding was provided to build a second one. Additionally, a small agro-processing facility is being build, as well as a knowledge centre to share the cooperative's experiences with micro-hydro energy.

Similarly, a close working relation is observed between social enterprise YRE and NGO Hivos. Founded by Hivos, YRE has been supported and trained by the NGO over the past four years. Currently, YRE operates independently regarding management and execution of the projects.

Being founded for only one and a half years, cooperation between private service company RESCO and the implementing NGOs can be considered strongest. To acquire other maintenance jobs or to distribute more technologies, RESCO is dependent on Hivos both for funding and capacity development. Not only did the NGOs form and train RESCO, employees of the NGOs are the main shareholders of RESCO. An expert from NGO Winrock International explains why:

'The entire concept of doing maintenance on renewable energy installations does not exist in Indonesia. There have been thousands of solar panel projects in Indonesia, but none of them has been sustainable. For a local Sumbanese entity it is difficult to have a good understanding of the renewable energy sector in the rest of Indonesia, let alone for the rest of the world. […] International NGOs should stay involved as they have a helicopter view, they know the priorities. If we don't stay involved, if we don't do it right, it will fail again'.

Thus, even after the NGO project periods end, actors from the NGOs believe their continued involvement is necessary to ensure sustainability of the renewable energy projects and RESCO.

Cooperation amongst first-level institutions
Formal and informal interactions between the newly-formed institutions are observed. Social enterprise YRE holds official ownership over the lanterns rented out by private service company RESCO, to allow RESCO to further build its capacity before taking on more

responsibilities. Cooperative Kamanggih helps RESCO with choosing agro-processing agents and serves as the construction partner organisation for YRE. As the manager from YRE further explains:

'Within Sumba, it is a very small community of NGOs and local organisations, they all interact with each other very frequently. Not only professionally, but also privately everyone is very engaged. For example, when there is a death in the family of the Kamanggih cooperative leader, the staff from YRE and RESCO would visit the funeral'.

Such close connections amongst the first-level local institutions can generally be attributed to Sumba's culture, which is entrenched with strong senses of community and solidarity. Overall, the examples show how local institutions work together in the niche to ensure projects' outcomes are successful. Hence, their cooperation strengthens network connections contributes to niche development.

Cooperation between first-level and second-level institutions
Private service company RESCO visits the PV schools, energy kiosks and agro-processing agents on a monthly base to collect payments. Besides this, contact is limited. Social enterprise YRE is responsible for choosing the construction partner organisations and bio-slurry distributors. As a result, their interaction exceeds pure business contact, with strong informal relations between YRE and their distributors. For example, those who YRE invited to become bio-slurry distributors are often people that they personally know.

Involvement of users in the network
The newly-formed institutional structures serve important roles to engage technology users in the network. Being part of the local community, cooperative Kamanggih has strong, informal ties to community members. For social enterprise YRE and private service company RESCO, the second-level institutions serve as local agents in the communities. Potentially, these local agents play vital roles in transferring knowledge and experiences from users in communities to the centre of the network, as is discussed in the next results chapter.

Moreover, connections amongst second-level institutions and users in different communities are generally absent. This can be related to the remote settlement patterns and absence of mobile phone services. Nonetheless, respondents indicate that interacting with other local agents would be beneficial to share experiences and improve their businesses.

5.2. Convergence of expectations

Regarding the voicing, shaping, and alignment of expectations, it is observed that the newly-formed institutional structures provide a platform to align diverging expectations of NGOs, investor and the government within the niche.

The government makes valuable contributions to enhancing electrification rates by giving out free solar home systems and pushing the state electricity company to extend grid connections. Yet, communications to the implementing NGOs about which communities are targeted is lacking, leading to overlapping intervention areas and diminished effectiveness of electrification efforts. Simultaneously, whilst the NGOs are trying to introduce the concept of

paying for energy services, the government's distribution of free solar home systems confuses communities, undermining Hivos' efforts to create a sustainable renewable energy and maintenance market.

Interestingly, RESCO seems to provide a platform to align these diverging expectations between the government and international NGOs, within Sumba and beyond. As explained by the project manager of NGO Hivos:

'From our experience, the Indonesian government will be interested to work with RESCO when they see that it works, this is what we had to do for the biogas project [social enterprise YRE]. With RESCO we can convince the government that this is a good solution, as long as we show a good track record.'

A response of a representative of the Indonesian government confirms this alignment of expectations:

'We do think RESCO can be a good model to ensure the sustainability of off-grid installations. In the future we can be open to working with RESCO to distribute our renewable energy technologies, also on other islands. But we first need to study the operations and success of RESCO.'

Also for the other NGOs and investor, RESCO provides a platform to align expectations. For example, the director of investment company Village Infrastructure Angels indicates that both his company as NGO Hivos are dependent on RESCO to manage their renewable energy technologies. As a result, the two parties are not only forced to cooperate, but also to share their experiences with the renewable energy technologies and management structures.

As an official SII stakeholder, social enterprise YRE is able to more directly shape and align expectations amongst NGOs. Cooperative Kamanggih also aligned expectations amongst the NGOs IBEKA and Hivos, who worked together on the micro-hydro project. Unlike RESCO and YRE, the cooperative is further able to capitalise on both their local presence in the community and strong connection to NGO IBEKA. Herewith, they can facilitate alignment of expectations between the community and the NGO. Yet, as they are primarily focused on the local community, the cooperative's contribution to shaping of expectations within the entire network is limited.

5.3. Niche-level learning

5.3.1. Learning on technical optimisation

Within the SII niche, the NGOs play an important role in providing extensive knowledge on renewable energy technologies and their local fit. The initial choices on types of renewable energy technologies is primarily based on previous project experiences and a trial conducted by the NGOs.

The newly-formed institutional structures play a substantial role in further optimising renewable energy technological choices, for which information is shared throughout the

niche. For example, private service company RESCO and cooperative Kamanggih collaborate in choosing appropriate solar home systems to distribute to remote community members in the area of Kamanggih, who are not connected to the micro-hydro grid. Whilst the cooperative has strong knowledge on the locality and the needs of the users, RESCO has experience with distributing the technologies. As a result, the two institutions complement each other in learning on technical optimisation.

5.3.2. Learning on social optimisation

Social optimisation refers to learning on user preferences, user barriers to adoption, and delivering proper maintenance and distribution services. Social optimisation is indicated by all NGOs as a crucial component of developing a sustainable renewable energy niche in Sumba. Again, international actors have transferred knowledge from previous experiences to the SII niche, emphasising the key to successful social optimisation is the availability of management and maintenance services for the renewable energy technologies. This is exactly the reason why the NGOs created cooperative Kamanggih, social enterprise YRE and private service company RESCO.

Moreover, the newly-formed institutions are the first ones to notice and act upon feedback on social optimisation. As a first example, the micro-hydro installation in Kamanggih proved to generate a large excess of energy, whilst many households were struggling to pay the monthly fees for electricity. The cooperative quickly responded by signing a contract with state electricity company PLN. Excess electricity is sold to the PLN grid, and local households benefit from the lower prices offered by PLN. Sumbanese culture is highly entrenched with modesty, and locals would not easily indicate their struggles to foreigners. It is likely that without having an institution as rooted in the local society as the cooperative, such problems would not easily be recognised and acted upon.

Social enterprise YRE contributes to learning processes primarily through its close and personal relations with several influential bio-slurry distributors in East Sumba. Via their farmer-group networks YRE is able to collect feedback on user barriers to bio-slurry adoption.

In the case of RESCO, the second-level local institutions have potentially a vital role in learning on social optimisation, providing RESCO with ‘eyes’ in the communities to analyse user preferences and barriers to adoption. RESCO further contributes to social optimisation by being flexible in the business agreements they have with the various PV schools, energy kiosks or agro-processing agents. In this way, they can ensure technologies fit with the unique opportunities and problems in each locality.

5.3.3. Co-creation of knowledge

Co-creation of knowledge is an important aspect that benefits technical and social optimisation. However, knowledge sharing between RESCO and the PV schools, energy kiosks, and agro-processing agents is limited. As indicated by the project manager from NGO Hivos, it is Hivos’ tasks to further develop these skills:

'RESCO should and can be responsible for evaluating the projects. To make sure learning takes place, also between the agents and kiosks, and barriers to adoption are overcome. But they still need to be coached and managed. Hivos realised RESCO is still an infant regarding management capacity. Hivos has been grooming YRE since 4 years now, so they can do such management, but also YRE can still be improved. It takes a long time.'

As mentioned by the monitoring and evaluation officer from NGO Hivos, it is important that the local agents get inspired to engage them in co-creation of knowledge:

'In the past, the cooperative [Kamanggih] was sent to Kalimantan [another Indonesian province] to study about credit unions. They were inspired to create a saving and loan service for the cooperative members. When people meet each other, they get inspired and learn from other businesses.'

An example of social enterprise YRE further points to the potential of local institutions to stimulate co-creation of knowledge. Initially, NGO Hivos made an educational video of successful Javanese farmers to stimulate and educate Sumbanese farmers about using bio-slurry as fertiliser. YRE acquired feedback and quickly understood that Sumbanese farmers could not relate to the video, with farmers from different landscapes speaking in foreign dialects. YRE decided to organise workshops in which successful Sumbanese bio-slurry producers teach other farmers, to ensure participants can relate to the so-called 'best champion'.

Cooperative Kamanggih stimulates co-creation of knowledge through its cooperative structure. This provides opportunities for members to indicate their needs and share experiences. Furthermore, cooperative Kamanggih is now building a knowledge centre as mentioned before. The knowledge centre will be used to further teach their own community members and other communities about the benefits of renewable energy and the opportunities it provides for enhancing livelihoods. The examples of YRE and Kamanggih cooperative imply the substantial benefits of having local institutions with strong management skills, who can understand cultural meanings and preferences towards learning. Moreover, they can ensure continuous learning takes place, also after NGO support ends.

5.4. Market creation

5.4.1. Creation of appropriate business models

All NGO experts indicate that market creation is paramount to making renewable energy programmes succeed. By creating a viable market for renewable energy, businesses that provide highly-needed maintenance service become income-generating, benefitting sustainability of the technologies.

For cooperative Kamanggih, selling electricity from the micro-hydro to the grid provides substantial income, ensuring financial sustainability of the cooperative. In contrast, as a social enterprise, YRE is completely dependent on donor funding. Although they contract

construction partner organisations to find potential users and install bio-digesters, these organisations are paid from YRE's funds, and hence business models depend on donors.

The creation of appropriate business models is most applicable to RESCO, being a private company. RESCO is financially dependent on the performance of the PV schools, energy kiosks, and agro-processing agents. Yet, there is only a marginal space in which business models are appropriate. Sumba is a sparsely populated island, with substantial travel expenses to reach users. Simultaneously, renewable energy technologies are quite expensive, whilst the local population is able to pay minimal prices for them. As explained by the General Manager of RESCO: *'if the price would be higher price the technologies would not be accessible for the community members. But if the price would be lower, RESCO would not be able to exist.'* As a result, it is crucial that PV schools, energy kiosks, and agro-processing agents perform optimally, which requires continuous evaluation of the appropriateness of business models.

Agro-processing agents mainly contribute to appropriate business model development by enabling customers to pay in crops. Herewith, they play a crucial role in connecting international investors to impoverished farmers that struggle to pay in cash. However, payment collection costs for RESCO exceed profit from the agro-processing business. As discussed before, agro-processing agents additionally lease out PayGo systems that are more income-generating. This points to the flexibility of RESCO in matching different technologies with distributors, contributing to the creation of appropriate business models.

An agro-processing agent showing all the revenues he made in corn, which he will sell in the market.

The PV schools' main contribution to appropriate business models is their strategic location; children visit schools 6 days a week. Herewith, the majority of community members are able to access the lanterns. Moreover, schools receive a yearly budget from the Indonesian

government, from which they can pay RESCO's monthly fee. This provides a stable income source for RESCO.

The main rationale for working with energy kiosks is their established business mind-set, possibly contributing to successfully running a lantern business. However, 2 out of the 5 energy kiosk owners visited found the lantern business a burden, as they had to be present all day to welcome customers. Simultaneously, financial benefits are considered low. This reduced their motivation to promote the business. This research finds that RESCO can improve its efforts in analysing strategic locations of their local agents, which would benefit the company's financial sustainability. It is observed that kiosks closer to main roads, weekly market places, or transport hubs are more successful in finding customers that regularly charge lanterns than those who are not.

Moreover, the evaluation of charging frequency could further optimise performance of the business case. Although RESCO estimated lanterns would be charged 14 times per month, this research reported a significantly lower average of five times (as confirmed by CIRCLE Indonesia's (2018) evaluation report). The main reasons that respondents indicate are inability to pay, distance to the charging stations, and only using the lantern sporadically as a torch. Relocating lanterns and technologies would therefore improve RESCO's business case. This is also indicative of the benefits of working with leasing systems, providing opportunities to keep an overview on usages, making sure technologies that are not used or broken can be tracked down and possibly relocated or replaced.

5.4.2. Stimulating local entrepreneurship

The creation of a renewable energy market also requires the stimulation of local entrepreneurship. However, in a sparsely-populated society like Sumba in which the majority of people are subsistence farmers, stimulation of local entrepreneurship can be difficult. As indicated by the manager of YRE:

'*The sense of competition here is very low. Sumba has a highly supportive society. People do not have to think about doing business, they always have relatives who can support them. The society really comes first here, there is no discipline to start businesses. Working with cooperatives, local organisations like YRE and RESCO works really well. They think about profits, but also have a sense for the local reality. They have a sense for the society, they do not think purely in economic terms.'*

Thus, the role of newly-formed institutional structures are central in stimulating entrepreneurship. Whilst cooperative Kamanggih mainly creates entrepreneurial opportunities for business using energy services, YRE and RESCO primarily provide business opportunities for the distribution of technologies. This can be related to differences in technology type and institutional structure.

In Kamanggih, connections to the micro-hydro grid stimulates various types of business opportunities. Local households use electrical tools and appliances to make and sell furniture, clothes, and baked products. Shops can extend opening times and use refrigerators. Schools and health clinics could improve services due to electricity

connections. Moreover, the connection to electricity allows the cooperative to build an agro-processing facility. This will provide additional income opportunities for the local community, by creating job opportunities and providing an outlet to which farmers can sell their crops. Overall, respondents indicate that access to electricity has boosted Kamanggih's economy substantially.

Private service company RESCO and social enterprise YRE primarily stimulate entrepreneurship opportunities for those promoting and spreading the renewable energy technologies. This can first of all be attributed to the types of technologies distributed; lanterns and PayGo systems can only be used for lighting, households can merely bring corn to the agro-processing machines, and the bio-digesters are primarily used for cooking. Although respondents indicate that these benefits create additional time for existing productive activities, new business opportunities are not explicitly created. A second explanation lies in the institutional structure; the cooperative's local presence compared to the regional function RESCO and YRE serve. The prior has strong insights into business opportunities that fit the locality, as reflected in the agro-processing industry. RESCO and YRE are dependent on the second-level institutions to ensure renewable energy technologies match local demand and a market for renewable energy services is created.

However, business opportunities for the PV schools, energy kiosks, and agro-processing agents are currently limited or unexploited. This is caused by several factors. First, respondents indicate that income from the business is relatively small as mentioned before. Second, the energy businesses are side activities, partly as a result of the low incomes. Farming or regular business activities are more income-generating for respectively farmers and kiosk owners. They see the energy business primarily as helpful for the community, with personal income opportunities receiving less priority. As a result, the agents and kiosk owners are not stimulated properly to expand existing renewable energy businesses or analyse the market for new business opportunities. For PV schools, teaching is the priority. Hivos provided so-called vision trainings to PV schools, to establish a five-year business plan in which the school can start selling other energy products. However, all schools indicate a lack of time is the main obstacle to realising this plan.

Yet, the business model of the PayGo systems indicate that it is possible to provide profitable business opportunities to local agents. Although at the time of the research PayGo system were only distributed for one month, all agro-processing agents indicated its large contribution to their incomes. Additionally, various kiosk owners and head of villages indicated they would like to start selling such PayGo systems. As the higher price of the systems mean that they are not accessible for all community members, it seems a viable option for RESCO to diversify products sold at distribution points. As indicated by RESCO's general manager:

'The idea is that when the kiosks or agents are successful, they can also start selling batteries, solar home systems, solar charges etc. On the long term, using solar will be easier, the local agents can provide all sorts of technologies in the villages. RESCO hopes to reach that state.'

Similarly, YRE is struggling to stimulate local entrepreneurship. Business opportunities are mainly created for construction partner organisations that build the bio-digesters. YRE's funding period recently terminated, meaning that households have to pay the full price for bio-digesters with resulting declines in demand. YRE is now focusing on developing a bio-slurry market, for which existing bio-digesters can be used. However, profits for bio-slurry distributors are quite low, although the relatively wealthy distributors do not consider this as a problem, also primarily aiming to help the community.

5.5. Summary of the chapter

The results in this chapter are used to answer the sub-question: *How do the newly-formed institutional structures contribute to renewable energy niche development processes?* Table 9 summarises the observed and potential contributions of the newly-formed institutional structures to the niche development processes. Overall, it can be analysed that the newly-formed institutional structures contribute to niche development processes in three ways: 1) they strengthen the niche network through informal relations and by aligning expectations amongst NGOs, 2) they connect NGO support to local users, and 3) they stimulate local entrepreneurship.

Table 9. Summary of observed contributions (X) and potential contributions (*p*) of the newly-formed institutional structures to niche development processes.

Niche development processes	Cooperative Kamanggih	Social enterprise YRE	Private service company RESCO
Actor network creation			
Connecting NGO resources to users	X	X	X
Strong informal relations amongst new institutions	X	X	X
Regional function: connect to many localities		X	X
Connecting 2nd-level institutions & users		X	*p*
Broaden network by finding new funders/projects	*p*	*p*	*p*
Convergence of expectations			
Shaping of expectations between NGOs and government		X	X
Shaping of expectations amongst NGOs	X	X	X
Providing direction for innovation processes in niche		X	*p*
Incorporation expectations of users	X		
Niche-level learning			
Continuous learning technical optimisation	X	X	X
Continuous learning on social optimisation	X	X	*p*
Stimulate co-creation of knowledge 2nd-level institutions		X	*p*
Stimulate co-creation of knowledge users	X	*p*	*p*
Market creation			
Creation appropriate business models			X
Stimulating entrepreneurship using energy services	X		*p*
Stimulating entrepreneurship spreading energy services		X	X
Regional function allows broad market stimulation		X	X

First, informal relations between cooperative Kamanggih, social enterprise YRE and private company RESCO enhance cooperation amongst the local actors and strengthen the niche network. Moreover, the institutions provide a platform in which NGOs cooperate and expectations within the niche can converge.

Second, the newly-formed institutional structures ensure continuous connections between NGO projects and local communities, benefitting learning processes in the niche. Cooperative Kamanggih is highly embedded in the locality whilst also having strong connections to NGO IBEKA, benefitting social optimisation of technologies. Social enterprise YRE and private company RESCO serve a broader regional function and hence connect to users via the second-level local institutions. The first-level institutions have a closer relation to NGOs, whilst the second-level institutions have extensive knowledge on local opportunities and challenges. As a result of working with two levels, communication and feedback collection is more difficult, providing room for improvement for YRE and RESCO to manage learning processes. Connections amongst the second-level local institutions are generally lacking, whilst bolstering these connections could further strengthen the niche network.

Third, the newly-formed institutional structures have a crucial role in stimulating local entrepreneurship. Whilst market creation is considered difficult in Sumba's remote and poor society, the newly-formed institutional structures are not solely driven by financial incentives. They capitalise upon entrepreneurial opportunities even when they are not very profitable. Cooperative Kamanggih is most successful in creating opportunities for businesses using electricity, yet its impact area is confined to the Kamanggih district. Private company RESCO and social enterprise YRE push market creation across the island, primarily by providing business opportunities for the second-level institutions that distribute technologies. The PV schools, energy kiosks and agro-processing agents can ensure the supply of technologies matches with local conditions, by having respectively an accessible location, a business mind-set, and accepting payments in crops. However, it is shown that RESCO needs to improve its management skills to evaluate appropriateness of business models, to ensure sustainability of the created renewable energy market.

Thus, the newly-formed institutional structures serve important roles in stimulating renewable energy niche development processes on Sumba. However, the substantial influence of NGOs in niche development processes is clearly demonstrated throughout this chapter. Without financial and management support, it seems that the newly-formed institutional structures would not be able to successfully fulfil what seems to be their most important role: to sustain the niche in the long-term.

Chapter 6: Results learning-based participative processes

This chapter discusses the results regarding sub-question 3: *How do the newly-formed institutional structures contribute to learning-based participative processes of renewable energy experiments?* Learning-based participative processes are conceptualised using the bottom-up learning-based approaches to development interventions (see Table 10) as discussed in Chapter 2, according to which the results in this chapter are structured. It is examined how each of the newly-formed institutional structures – cooperative Kamanggih, social enterprise YRE and private service company RESCO – contribute to the learning-based participative processes, of which a concise overview is given at the end of the chapter.

Table 10. The learning-based participative processes.

Learning-based participative processes
Project design and management
Local resource mobilisation
Local fit of technologies
Organisational structure
Flexibility in implementation
Strong Leadership
Raising awareness
Communication and monitoring
Community-level learning
Voicing of opinion
Capacity building
Local participation
Inclusivity
Local ownership

6.1. Project design & management

6.1.1. Local resource mobilisation

An essential element of creating learning-based and participatory development projects is using and building on locally available resources and capabilities. By creating and supporting cooperative Kamanggih, social enterprise YRE, and private company RESCO, the NGOs have capitalised upon locally available capabilities. Furthermore, when the manager from investor Village Infrastructure Angels was asked about the rationale behind working with second-level institutions, he answered:

'Who else would be running the projects?! The local agents are the only ones who can have a direct relation with the people in the villages. You need someone who is in the village all the time, who knows how to gather the money, but also how to promote the technologies, and who can see the problems and opportunities. You cannot give that responsibility to a few people living in the city or to NGOs. You need to use the existing capabilities in the communities.'

This further implies the importance of working with local agents, to capitalise upon existing capabilities.

6.1.2. Local fit of technologies

Whilst the niche development processes – as discussed in the previous chapter - are primarily able to analyse continuous learning on technical optimisation amongst the central niche actors, the learning-based participative processes allow a closer look as whether local users are able to provide input into technology selection to ensure they fit the locality. All respondents indicate they have never been asked for input on technology selection. Nevertheless, the local institutions do provide opportunities to collect feedback from the potential users. Table 11 summarises how cooperative Kamanggih, and to a lesser extent private service company RESCO, do so and use feedback to change technological choices and structures.

Table 11. Ability of local population to indicate needs regarding technology selection.

Technology	Wanted by % respondents (users and non-users)	Improvements indicated by respondents	Ability to provide feedback & change technology
Micro-hydro *(cooperative Kamanggih)*	100%	Costs for electricity can be lower. Live too far to get connected to micro-hydro.	*Yes.* Cooperative Kamanggih conducts trial for new micro-hydro installation to analyse how much people would like to pay. Also, the cooperative analyses possibility to provide solar home systems to those unconnected.
Bio-digesters *(YRE)*	86%	Too expensive. Break easily. Require too much cleaning.	*No.* Social enterprise YRE realises some of these problems through informal relations, but the technology cannot be changed.
Lanterns *(RESCO)*	100%	Ownership: too much money before owning the lanterns and burden to bring it away to charge.	*Limited.* Users indicate these improvements to the energy kiosks and PV schools, but feedback collection by RESCO is insufficient.
PayGo systems *(RESCO)*	100%	Too expensive.	*Limited.* Agro-processing agents gather information that it is too expensive, but feedback collection by RESCO is insufficient.
PV agro-processing mills *(RESCO)*	100%	Mills break easily.	*Yes.* Agro-processing agents can contact RESCO, who is working with investors to improve technology.

Table 11 shows that cooperative Kamanggih is primarily able to collect and act upon feedback from the local community on technology selections. Due to their prior experiences with managing a micro-hydro, they can improve the inclusion of the local population in examining technological choice for new projects. They are currently conducting trial periods with households that will be connected to the new micro-hydro installation. At the same time, the cooperative realises the micro-hydro does not provide the right technological fit to all households in the community. To cater their needs, the cooperative actively visits households, asking for their livelihood needs, and in this way examining the best technological choice.

For the technologies offered by private service company RESCO, the local agents are able to collect feedback on technology selection and improvements due to their embeddedness in the community. However, it is observed that RESCO does not structurally collect such information, especially for PV schools and energy kiosks, limiting the right fit of technologies with localities.

A woman shows how she manually grinds corn, which takes her around three hours each day. The agro-processing machine can grind the same amount in only three minutes, against a cheap price. As a result, the agro-processing service are highly wanted by community members.

Interestingly, the bio-digesters offered by social enterprise YRE were analysed by international NGOs to be a good fit with Sumba's society, as people traditionally hold cattle and primarily collect firewood for cooking. Yet, it can be noted that the technologies are prone to quick degradation and too expensive for most people. Due to YRE's institutional structure that solely focuses on one technology, taking into account such feedback to change technological choice is not possible.

6.1.3. Organisational structure and flexibility

When evaluating the fit of the specific organisational structures of the three institutions with the renewable energy technologies and localities, an interesting observation can be made. The micro-hydro installation is a relatively expensive static technology. This requires a highly

motivated institution that supervises the building process and takes on management responsibilities to ensure sustainability of the installation. The organisational structure of a cooperative, seems to allow a good fit with the innovation; it is highly embedded in and committed to the locality – hence could be considered static as well –, allowing long-term commitment to the micro-hydro installation.

In contrast, the technologies leased out by RESCO are relatively inexpensive and mobile. To ensure that they both benefit the largest amount of people and provide continuous income to RESCO, a more flexible organisational structure is required. Working with the local PV schools, energy kiosks, and agro-processing agents enables RESCO to safeguard this flexibility. When users do not charge their lanterns or PayGo systems for more than 2 months, the local agents can redistribute the technologies. Moreover, the flexible organisational structure can potentially ensure technologies and business models fit the varying localities across the island, as RESCO is able to distribute different technologies and have varying agreements with each agent. As explained by RESCO's manager:

'In general for RESCO it is important to lease out many different technologies, we need the time before we know which products work and which don't. […] Different areas in Sumba show different results, each village will be managed based on their different cultures and experiences. RESCO will have a different relation to each community, and will offer different technologies and agreements.'

It is observed that the second-level local institutions further enhance flexibility, as various PV schools, kiosk owners, and agro-processing agents indicate that they allow users to pay in advance. Such flexibility contributes to inclusivity, as local population's income fluctuates throughout the year, correlated to harvest seasons.

The organisational structure of social enterprise YRE can be considered less flexible than that of RESCO but less rigid than that of cooperative Kamanggih. As the bio-digesters are relatively expensive to acquire for households, it is important to determine a good fit with the household's economic activities. The construction partner organisations serve an important role to assure this. They serve multiple communities, which fits the technology well; after construction of the digester not much involvement of external parties is needed. Yet, it was noted before that the bio-digesters break down easily. Having institutions in place that are more embedded in communities, and hence more involved in noticing and acting upon such problems, would benefit YRE's structure.

Overall, the newly-formed institutional structures within the SII niche demonstrate the important role they play in assuring development projects' organisational structures fit the innovation as well as the locality, although with varying levels of flexibility being appropriate.

6.2. Strong leadership

6.2.1. Raising awareness

Strong leadership that is able to raise awareness is crucial to promote and inspire the population to adopt renewable energy technologies (Romijn et al., 2010). To this end, the role

of the newly-formed institutional structures is paramount in the SII niche, to capitalise upon the strong, informal connections that can be found in Sumbanese communities.

In the case of Kamanggih, the head of the cooperative proves to play a crucial role in raising awareness. The majority of respondents in Kamanggih and surrounding localities indicate that they know him and trust him. As the intervention is community-based, it is relatively easy for the cooperative to spread information about new projects and technologies.

In the case of private company RESCO, the most important responsibilities to raise awareness lie with the second-level local institutions, who promote the technologies on a day-to-day basis. The three PV schools visited promote the lanterns by organising parent meetings once a year, which is in all cases sufficient to lease out all lanterns. Kiosk owners primarily promote the lanterns when people visit their shops. One kiosk agent set up what he called an 'early-bird registration', leasing out all lanterns even before he received them. All kiosk owners as well as agro-processing agents explain that the technologies are promoted informally, often through word of mouth, and hence they do not have to put in much effort. As one agro-processing agent explains it: *'as soon as a few people see or use the technologies, all surrounding hamlets will also know about it. Words spread very easily here.'*

Similarly, social enterprise YRE capitalises upon existing, strong informal relations throughout Sumba. As explained before, YRE benefits from the influential bio-slurry distributors, using their network to spread awareness. This is indicated by responses from two bio-slurry distributors; farmers that live as far away as a three-hour motorbike trip come to buy their bio-slurry.

6.2.2. Communication and monitoring

The newly-formed institutional structures allow continuous communication with beneficiaries due to their local presence, although with varying degrees. Cooperative Kamanggih has a crucial position in enabling communication and monitoring processes, as its staff members are all from the local community. It primarily acquires monitoring information through informal processes.

As discussed before, for social enterprise YRE and private business RESCO communication processes are more complex, as they work with the second-level institutions. YRE receives monitoring information primarily through informal relations with bio-slurry distributors and constructions partner organisations. RESCO is still highly dependent on NGO Hivos to conduct monitoring activities. Their monthly visits to all communities to collect payments provide important communication and feedback moments with local agents and community members, although RESCO does not capitalise on them. This is reflected in this statement by RESCO's director:

'If there is a problem with the technology, RESCO can solve it. If it is about problems with the community [referring to low charging frequencies], the agents should mainly solve it themselves. We tell the agent: the money is in the village, you have to take care of it.'

Yet this research finds that although local agents are situated within the communities, their capacity to properly monitor the projects is often lacking.

6.3. Community-level learning

6.3.1. Voicing of opinions

Voicing of opinions consists of the ability of local populations to share their views and experiences to enhance community-level learning processes. As the cooperative directly communicates with community members, their local consultation processes are more advanced and inclusive. Respondents indicate that they feel open to communicate with the cooperative, even about sensitive issues. As explained by one respondent: *'I will tell the cooperative what I think about having the electricity [referring to trial period run by the cooperative], and also when it is too expensive to pay for it'.* The manager of IBEKA attributes this openness of community members to the cooperative's accountability towards its members, with trust relations as the most important factor:

'What is highly important is trust. Trust from the community to the management of the cooperative. If people trust the cooperative, they will pay and say what they think is needed. If leaders commit fraud or do not listen to the people, there will be no trust. In many places working with cooperatives does not work. In Kamanggih it does, because the management has their hearts with the community.'

For social enterprise YRE, trust relations also facilitate voicing of opinions. However, this is only the case for users that know YRE's staff personally. Other users do often not feel connected enough to either YRE or the construction partner organisations to ask for maintenance services. Similarly, non-user respondents indicate they do not know who to consult when they have difficulties paying or building the digesters, as the construction partner organisations are often not present within communities.

Similarly, for private service company RESCO it is found that users, non-users, and second-level institutions are 1) not asked to share their views by RESCO and 2) often do not voice their opinions themselves out of modesty. For one PV school, RESCO did take into account feedback. The school proposed to change the payment system for charging lanterns to 15,000 IDR (90 eurocents) per month for unlimited charging instead of 1,500 IDR (9 eurocents) per charging. Interestingly, this case shows how power structures inhibit proper collection of feedback from the local population. Whilst it seems sufficient that the PV school organised a parent meeting in which parents were consulted, interviews with the parents imply that the local population was not in a position to actually voice their opinion. As two respondents (both users, female and male) explain:

'I need the lantern so I will follow the new agreement. There was not really any opportunity to say my opinion, I am also not a public speaker. Everyone just agreed, no one of the parent said anything. The principal must know what is best.'

'*It is better to pay 15,000 IDR each month. But I could not pay already for two months now, I am trying my best to pay this month. But the new system is better. If the school management says it, we will always agree'.*

This modesty is also reflected in the relation between RESCO and the second-level institutions. Throughout the field research, various PV school staff members, energy kiosk owners and agro-processing agents expressed comments on RESCO's business model, but indicated they were not in the position to articulate these. This is reflected in the following statement of a PV school teacher:

'We [the school staff] think the profits from the lantern business are too small. But because it is RESCO's policy, we will just follow it. It is not polite to argue about the price.'

Thus, RESCO can improve both its collection of feedback as well as ensuring the local population is properly stimulated to voice their opinions. For the latter, it is important power structures are taken into account.

6.3.2. Capacity building

Capacity building is an important aspect of putting 'foreign' renewable energy technologies in the hands of locals. The NGOs play the most important role in teaching the newly-formed local institutions both technical and management skills. The newly-formed institutional structures are responsible for providing so called 'socialisation' trainings to the communities, ensuring their capacity in managing and using the technologies is improved. As explained by RESCO's managing director, local staff understand how to most effectively explain about the foreign, and often found difficult, concepts of renewable technologies:

'We use really simple, easy to understand, language and metaphors. We call it the philosophy of the mother:
The PV panel is like a father looking for money. The controller is like a mother, she controls the moneys that she received from the fathers. The battery is like the savings of the money in a bank. The three lamps are like the sons: the mother divides the money between them, if there is no money in the bank (or electricity in the battery), the mother cannot give money to the sons.
You need such language for remote people, you really need to know about their background. This is the strength of RESCO, we are all local.'

This implies the importance of working with local institutions to enhance the local population's capacity to understand and adopt renewable energy technologies, which was also found for social enterprise YRE and cooperative Kamanggih.

6.4. Local participation

6.4.1. Inclusivity

All NGO interventions within the SII niche take a market-based approach, which inevitably affects inclusivity, especially regarding the poorest households. Within the three newly-formed institutional structures, different impacts are observed.

The micro-hydro installations managed by cooperative Kamanggih can be considered most inclusive, as all households received free connections to the grid. They pay relatively low

prices for electricity credit. For those who live too far from the grid, cooperative Kamanggih is trying to find alternative solutions, such as subsidised solar home system. Yet, not all households can benefit to the same extent from the electricity connection. Whilst some are able to buy sufficient electricity credit to use appliances such as fridges and electric tools, poorer respondents indicate that their income only allows them to pay for a few lights. Nevertheless, all respondents indicate that payments for electricity are fair and affordable for everyone. However, this business case is unique for the locality of Kamanggih and cannot be easily transferred to other localities. As indicated by the manager of NGO IBEKA:

'Kamanggih is very special in Sumba. People are close together here. In other areas it is much more difficult, people live one to two kilometres from the next house. This makes the costs of installation for a micro-hydro very high, especially for the transmission lines.'

Due to the remote settlement patterns, inclusivity of the technologies offered by private company RESCO are less inclusive. In various communities visited, many people had received free solar home systems from the government or bought their own solar home system in the market. As a result, energy kiosks sometimes struggle to find customers in their own community or lanterns are leased to households who do not specifically need the light. This is confirmed by an external evaluation of the SII programme (CIRCLE Indonesia, 2018), showing that amongst 600 lantern users 45% of users at PV schools and 30% of users at energy kiosks have access to other electricity sources (see Figure 9). Leasing out lanterns to such households reduces inclusivity, as those who really needed are excluded.

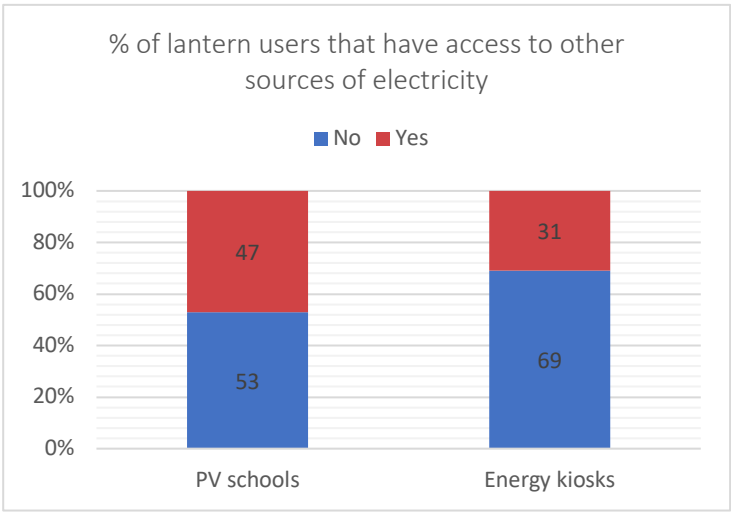

Figure 9. Percentage of lantern users that have access to other energy sources (primarily solar home systems) (CIRCLE Indonesia, 2018).

Exclusion of those who need it is illustrated by the answers that non-user respondents provided when asked why they did not have a lantern. Figure 10 shows that for PV schools, four respondents indicated that they had no money to pay the initial 50,000 IDR (3 euro) leasehold fee at the time the lanterns were leased out. Afterwards, all lanterns were sold out. The popularity of the lanterns can be explained by physical accessibility of charging stations

at schools. As children can take the lantern to school to charge, distance is not an excluding factor. Households that do not have children at school are excluded from the lantern business, but childless households substitute a minor part of each community visited.

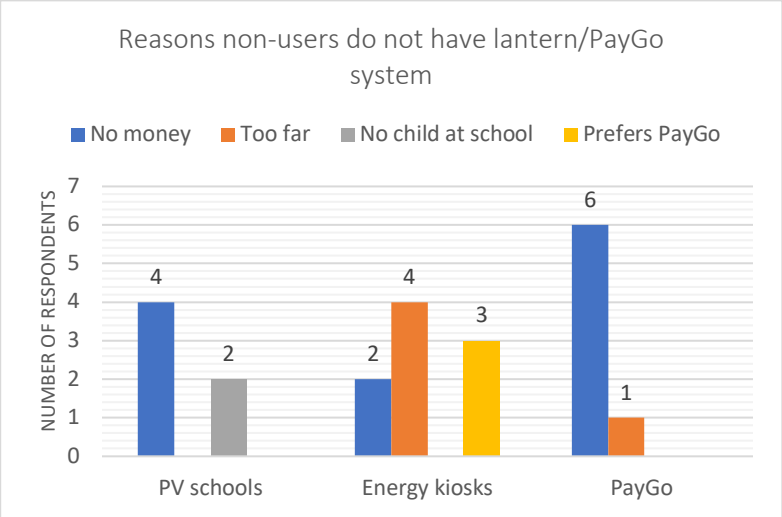

Figure 10. The reasons that non-user respondents do not have a lantern or PayGo system.

For the energy kiosks, the main reason for exclusion is distance. People living in the surrounding hamlets often found charging the lantern at the kiosk too time-consuming. In one community the kiosk agent actively tried to engage with people in the hamlets. Yet, charging frequency of these remote customers only averaged to twice a month, with many respondents having empty lanterns for the majority of the time. In one of the communities visited, the energy kiosk was located closely to an agro-processing agent leasing out PayGo systems. Various respondents indicate that they prefer this system above the lanterns, as they only need to be charged once a month, reducing exclusivity regarding distance. However, the majority of non-user respondents indicate that they cannot afford the PayGo systems. As the head of a community explains:

'People who really need the lights live in the surrounding hamlets. But they don't know about the lantern, as they live far away. Or they don't want a lantern because it is just too far away to charge it every time. They don't have a motorbike, they would have to walk three to four kilometres. For them the PayGo system would be better, but they don't have money for the PayGo system. So they will continue using kerosene lamps.'

In contrast, another agro-processing agent successfully leased out all his PayGo systems, mostly to people in surrounding hamlets. This indicates the difference in inclusion/exclusion patterns amongst communities in Sumba.

The agro-processing milling service was indicated by all respondents as very affordable. Non-users could not be found in any of the visited communities, indicating the high level of inclusion. This can be explained by the fact that all communities did not have a similar agro-processing service before, the low prices, and the ability to pay in crop.

Overall, RESCO's business structure affects inclusivity in heterogenous ways, related to the type of technology, other technologies offered in the area, physical characteristics of the environment, and the business models. This points to the flexibility needed in matching technologies with communities.

The bio-digesters offered by social enterprise YRE have low levels of inclusivity. Even when 70% of the price for the installation was subsidised by YRE and people only had to gather 30% of the costs in the form of materials, many people were excluded from the technology because they cannot afford it. Yet, the bio-slurry sold by the bio-slurry distributor is competitively priced, making it accessible for all farmers.

Another aspect of exclusion is the preservation of existing power structures, which can be observed in the cases of RESCO and YRE. Cooperative Kamanggih channels all income from the renewable energy interventions into new community development projects. In contrast, RESCO and YRE provide profitable business opportunities to only a few selected second-level institutions. As explained before, the bio-slurry distributors consist mainly of influential people. Additionally, energy kiosk owners are often relatively wealthy compared to the rest of the community, as they already own a business. Moreover, it was shown that a relatively large amount of people that rent lanterns already have access to other lighting sources. As a result, a local NGO expert indicates that the wealthier people in society are often able to benefit most from the renewable energy interventions, maintaining power relations and upholding patterns of exclusion.

Furthermore, it should be noted that gender balances amongst the institutional employees (first- and second-level) were roughly equal and both male and female benefit equally from the renewable energy technologies distributed.

6.4.2. Local ownership

By creating and giving responsibility to cooperative Kamanggih, social enterprise YRE, and private company RESCO for managing the renewable energy interventions, ownership over the technologies is literally and figuratively put in the hand of locals. By asking payments for electricity, the NGOs further try to enhance feeling of ownership amongst users. Yet, contributions of the newly-formed institutional structures to feelings of ownership amongst the local population vary and is primarily observed in the case of cooperative Kamanggih.

To enhance feelings of ownership, the cooperative signed agreements with all community members that required them to help building the micro-hydro installation, in order to receive a free grid connection. As explained by the head of cooperative Kamanggih:

'We explained to the community that they should help building the installation. The community members then understand how the electricity is generated and works, they feel ownership, they see it as theirs, and they feel the responsibility to maintain it.'

All respondents in Kamanggih indicated that they were proud of helping with the construction of the micro-hydro installation, indicating their motivation to adopt the innovation. They

realise that the income from the electricity generation is used by the cooperative to further help the community and are honoured to have the cooperative in their community.

For social enterprise YRE and private company RESCO it proves more difficult to stimulate ownership amongst their second-level institutions. The manager of YRE explains that over the years they got a good feeling for who makes a good construction partner organisation or bio-slurry distributors, which is primarily related to how responsible they feel for making the project successful. This indicates the importance of instigating feelings of ownership, which YRE is able to do through their informal connections and experiences.

In the case of RESCO, levels of ownership amongst the PV schools, energy kiosks, and agro-processing agents vary. It is observed that school management is often very dedicated to the lantern business, aiming to help the local community. Most agro-processing agents also show motivation to adopt responsibility of project success. As one agro-processing agent shared proudly:

'I never dreamt that something like this would happen to me. I am very happy I was chosen to become an agent. It provides good income opportunities for me and my family, and it helps the community. I am determined to make this a success.'

However, the majority of the energy kiosk owners indicate that they experience the lantern business as a side business, mainly to benefit from the lamps they receive. Nevertheless, all kiosk owners, school management and agro-processing agents indicate that they visit users who do not charge often, to ensure people use the lanterns properly. To stimulate further feelings of ownerships, RESCO's managing director explains that they are trying to build emotional connections to each local agent, school and kiosk owner, by always sending the same staff member to a location. This is meant to further involve them in the project and create trust relations with RESCO.

6.5. Summary of the chapter

The results in this chapter are used to answer the sub-question: *How do the newly-formed institutional structures contribute to learning-based participative processes of renewable energy experiments?* Table 12 summarises the observed and potential contributions of the newly-formed institutional structures to the learning-based participative processes. It can be analysed that the newly-formed institutional structures generally positively contribute to learning-based and participatory development in three ways: 1) they ensure project management fits with the technology and locality, 2) due to their local embeddedness they are able to raise awareness and train the local population in using technologies, and 3) they are able to foster local ownership of niche experiments.

Table 12. Overview of the observed (X) and potential (*p*) contributions of the newly-formed institutional structures to learning-based participative processes.

Learning-based participative processes	Cooperative Kamanggih	Social enterprise YRE	Private service company RESCO
Project design and management			
Local resource mobilisation	X	X	X
Local fit of technologies	X		*p*
Organisational structure: fit with innovation	X	X	X
Organisational structure: fit with locality	X		*p*
Flexibility in implementation	X		X
Strong Leadership			
Raising awareness through informal relations	X	X	X
Communication and monitoring	X	X	*p*
Community-level learning			
Voicing of opinions	X		*p*
Capacity building trainings	X	X	X
Local participation			
Inclusivity – ability to pay	X		*p*
Inclusivity – physical accessibility	X	X	
Inclusivity – overcoming power structures	X		
Local ownership	X	X	*p*

First, results show that the newly-formed institutions allow a match between technological choice and organisational structure, albeit with different characteristics. The cooperative's embeddedness in one locality allows strong management of a static micro-hydro installations. In contrast, private service company RESCO's flexible structure is better suited to lease out a variety of low-cost, mobile PV technologies across Sumba. Working with local agents, RESCO can ensure that technologies match with local demands across localities. Social enterprise YRE does not have agents based in each community, resulting in low abilities to both recognise local problems and act upon them. This implies the importance of having local representatives in each locality.

Second, such local embeddedness is beneficial for raising awareness for technologies and training local populations. All three newly-formed institutional structures are able to capitalise upon the strong, informal connections on the island to stimulate adoption amongst the local population. Moreover, as they understand the local culture, they are able to explain the technologies in language that is easily understandable for locals.

Third, the three newly-formed institutional structures are able to foster local ownership of niche experiments. For cooperative Kamanggih ownership is stimulated amongst users, whilst for YRE and RESCO this primarily holds for the second-level local institutions. Although it sometimes proves difficult to stimulate ownership amongst the local agents, all institutions indicate the importance of trust building.

However, the newly-formed institutions' contributions to inclusivity and local consultation differs. Cooperative Kamanggih ensures that all community members can benefit from renewable energy technologies and creates a trusting atmosphere in which community members feel open to voice their opinions. For social enterprise YRE and private service company RESCO this proves more difficult. This is both related to their business structures, with prices and distance to charging points reducing inclusivity, as well as their more figuratively distant connection to local communities. Although the local agents provide good communication channels to acquire input from the local population, existing power structure often inhibit the community members as well as the local agents to speak their minds.

Chapter 7: Discussion

The previous two results sections suggest that *the many complex (in)formal relations between first- and second-level institution*s are one of the most critical elements of local societal embedding of the renewable energy niche in remote places. In what follows, the contributions of the extensive network of newly-formed institutions will be discussed, followed by challenges and opportunities for the institutions to advance local societal embedding. Then, recommendations for effective institutional building blocks that contribute to societal embedding are provided, followed by the role of NGOs in pursuing these.

7.1. Newly-formed institutional structures as intermediary platform

The extensive network of newly-formed institutional structures can be considered an '*intermediary platform*', connecting to both a range of international NGOs and investors as well as users in many localities across the niche. Herewith, the network goes beyond the common NGO method of working with a single 'middle man' to overcome the classical dichotomy between 'givers' and 'takers' (Brass et al., 2012; Guerreiro & Botetzagias, 2018). The concept of an intermediary platform can be related to Blum et al.'s (2015) argument, who point to the role of a system-building intermediary for niche development. Such system-builders are able to collect, store, translate, and pass on knowledge on technologies as well as mediate between actors from different cultural backgrounds. The system-building intermediary should have access to international actors and be able to speak their 'language'. Within the SII, the first-level local institutions are able to do so. They work together with a range of NGOs and investors, providing a platform in which international actors converge expectations. Simultaneously, feedback from the village level is crucial (Romijn et al., 2010). This research finds that local agents - the second-level institutions - can play vital roles in transferring knowledge and experiences from users in communities to the centre of the network. Thus, instead of having one institution in place that is able to take on this system-building role, this research finds that it are *the interactions between first- and second-level institutions* that effectively enable mediating functions between a variety of local and global actors and contribute to niche building in remote areas.

This research further indicates that the interactions between first- and second-level institutions allow effective *market creation* for renewables. It is shown that in remote developing areas, it is crucial to build up appropriate business models and entrepreneurial opportunities to locally embed the renewable energy technologies. This research confirms previous findings that a broad distributor network most effectively targets users and eases the provision of maintenance service for pico solar technologies in remote areas (Byrne, 2011; Guerrero & Botetzagias, 2018; Rehman et al., 2010). Especially working with lease agreements is a viable strategy to bolster sustainability of the technologies and create entrepreneurial opportunities. The first-level institutions can guarantee maintenance services and can keep an overview of technology usage, whilst second-level institutions are provided with income-generating businesses. However, when working with larger technologies such as a micro-hydro installation, it seems more viable to have a strongly-embedded local institution in place that is able to manage the mini-grid, such as a cooperative. This is

indicative of the importance of having a variety of institutional structures in place that each fit the technology and locality.

Then the question arises how all these complex first- and second-level institutions are tied together within one network, leading to strong local embedding. Findings in the research emphasise the importance of *informal connections* between the institutions, with *trust relations* being an important aspect that holds the network together. This is reflected in the ways the first-level institutions cooperate, in terms of both sharing management expertise as well as selling technologies and services to each other. This research supports earlier findings that knowledge links tend to be informal, relational, and cultural amongst actors (Blum et al., 2015; Chang & Chen, 2004). The importance of trust-based, strong relations amongst the institutions is also suggested by Byrne (2011) and Kruckenberg (2015), who both stress that strong inter-organisational ties are needed to integrate renewable energy technologies in developing areas. Such strong ties enhance long-term collaboration, robust management, and knowledge transfer, which in turn benefit learning on local conditions that affect renewable energy adoption (Brass et al., 2012; Byrne, 2011). Interestingly, previous research finds that such trusting relations are often absent in developing countries, resulting in insufficient cooperation and a lack of niche-level network formation (Hansen & Nygaard, 2014; Romijn & Caniëls, 2011). The difference in findings can be related to the type of network actors studied. These studies focus on existing and competing businesses, who prevent cooperation to protect their own business case. In this research, the institutions are newly-formed and focus on different technologies. As a result, the institutional structures are designed to complement each other, allowing cooperation amongst them. To strongly embed an entire renewable energy niche, it seems imperative to have multiple first-level institutions in place that do not compete against each other but allow sufficient learning processes between them.

Furthermore, the findings show that informal trust relations between first- and second-level institutions are important to broaden the well-embedded centre of the network. Local institutions can use their tacit knowledge on the locality to select influential community members to promote renewable energy technologies, making use of their far-reaching and close-knit networks. Previous research (Mohamed et al., 2012; Pedersen et al., 2017; Rehman et al., 2010) confirms findings on the importance of informal relations to raise awareness on the technologies and train locals in using them.

7.2. Challenges and opportunities for newly-formed institutional structures

Although the complex interactions between first- and second-level institutions allow important niche development processes, it proves more difficult to truly include the local population in niche experiments. The findings of this research show that the more complex the relations within local institutional structures are, the more difficult it is to ensure inclusive and empowering learning and participation processes.

This is first of all reflected in analysing the engagement of second-level institutions. The findings show it is difficult for a first-level (regional) institution to effectively manage and engage with second-level institutions (local agents) that are spread out across a remote area. Effective communication is hindered by a lack of infrastructure, such as proper roads and a

mobile phone network. As confirmed by Blum et al. (2015), engagement would benefit from trust-based communication patterns between the first- and second-level institutions, yet this is difficult to establish in many remote areas. As a result, the local agents see the renewable energy interventions more as a top-down development project, which is beneficial for the community but not necessarily for themselves. The low profits on the business case further perpetuate this view. Consequently, they are not properly stimulated to either expand their businesses or provide feedback to the first-level institution when not directly asked for. This is especially the case for the service company, working with many local agents and offering a variety of technologies. The local agents are often not aware that they are embedded in a full network of other local agents, and hence that they contribute to the exciting prospect of stimulating a renewable energy transition. The social enterprise has a single clear-cut mission to foster bio-digester use and is herewith better able to engage second-level institutions in promoting their objective.

When the second-level institutions generally do not feel empowered, engagement of the local population also tends to be lower. As pointed out by Eswarlal et al. (2014) and Ortiz et al. (2012), community engagement in a renewable energy project significantly impacts its sustainability. The authors argue that continuous communication with the community is key to engagement, for which having a local agent that is easily approachable is most important. Yet, this research finds that purely having a local agent in place is not sufficient. Even when users interact with the local agents on a weekly basis, this research indicates that users are often merely seen as clients who have to accept the technology and its agreement. The local population receives a simple capacity building training, after which they are not asked for any feedback. The findings show that users are generally highly welcoming of the specific technologies and receive substantial livelihood benefits from them. Yet, their important opinions on specific issues, business models, or additional needs are not consistently taken into account.

Obtaining feedback from both second-level institutions as well as community members is further complicated by existing power structures. Results show that feelings of hierarchy discourage locals from freely expressing their views and concerns. This does not mean that patterns of social exclusion or power imbalances are reinforced (as mentioned by Ramos-Mejía et al., 2018), primarily because business models are not very profitable yet and hence local agents do not disproportionally benefit from the technologies. It rather manifests itself in cultures of modesty, which requires the creation of ‘safe’ spaces in which locals feel comfortable to speak. For example, whilst schools provide inclusive distribution points, the principal might not be in the position to provide such a safe space due to his function within the community. Again, trust seems to play a vital role in overcoming this problem.

The cooperative structure is best able to overcome issues of a lack of participation, empowerment and inclusiveness, as widely recognised within development studies (Booth et al., 2011). The results of this research show that the cooperative structure is highly embedded in a single locality, herewith building direct trust relations with the local population. As also found by Ortiz et al. (2012), working with community organisations allowed inclusive participation and feelings of ownership. Participation in building the micro-hydro strengthens identification of the local population with the project. Moreover, working in their own

community, it is easier for the cooperative to manage the projects, collect feedback, and creating a trusting atmosphere in which locals feel free to voice their opinions.

Not only does the example of the cooperative exemplify how a simpler institutional structure benefits learning-based participatory processes, it also points to potential improvements for working methods of second-level local agents, related to the stimulation of learning and feelings of ownership. A crucial reason to improve involvement of second-level institutions is simultaneously the primary shortcoming of the cooperative structure: the ability to spread knowledge throughout the entire niche. Having frontrunners who can do so is considered crucial to initiate structural change within the niche, for which cooperatives are often too focused on single localities (van Welie & Romijn, 2018).

Thus, the findings show that it is difficult for complex institutional structures in remote areas to sufficiently engage with the local population to instigate feelings of ownership. Yet, the local population does value and need the renewable energy technologies. This thesis argues that the most effective action for newly-formed institutions is to focus more on social learning. The concept of social learning underscores the continuous reflexivity needed to reform social practices in the face of complexity and uncertainty (Salvini et al., 2016). Although primarily used to transform agricultural practices in developing countries, this research points to its suitability for renewable energy transitions. Findings emphasise that the use of renewables in developing countries are inherently top-down technology transfers, but the accompanied changes in social practices are context-dependent, uncertain and complex. Social learning focuses on continuous learning via stakeholder participation, leading to collective action that is able to manage complexity and uncertainty (Collins & Ison, 2009). By creating learning platforms in which local agents and users can meet a few times per year, experiences and ideas can be shared. This can enhance feelings of local ownership, stimulate locals to pursue business opportunities, and provide valuable feedback moments to the first-level institutions. Such formalised meetings are considered especially relevant in remote areas, where interactions mostly take place in central hubs and not so much directly between localities as SNM assumes (Blum et al., 2015).

The final consideration is the use of market-based approaches. Although the creation of a renewable energy market contributes to the sustainability of technologies, findings show that it reduces inclusivity. Also argued by Jolly et al. (2012), market-based approaches to renewable energy diffusion have difficulty in researching the poorest of the poor. Although reaching the people at the base of the pyramid is a massive challenge in general, this research confirms findings of Rehman et al. (2010) that working with a variety of technology provides potential to target both poorer and wealthier households. Moreover, in remote areas distance to distribution centres can be problematic for inclusivity. The findings show that choosing appropriate local agents can reduce such problems. For example, working with schools enhances accessibility, whilst also benefitting development objectives of improving educational quality and raising school attendance. Additionally, the trust relations local agents have with the population can be used to allow payments in advance or in crops. Such flexibility further enhances inclusivity of market-based approaches.

7.3. Recommended building blocks for institutional structures

The previous discussions shed light on the main challenge for sustainability transitions mentioned by Romijn et al. (2010): to connect the environmental sustainability agenda (in this case purely focusing on renewable energy distribution according to niche development principles) with agendas of poverty reduction, local community development and capacity building. The discussions above indicate the potentially pivotal role of newly-formed institutional structures to contribute to both agendas. The following steps are recommended to build appropriate institutional structures that are able to do so:

The creation of a network of regional institutions working with local agents

Creating a variety of - first and second level - institutional structures, in order to establish a broad intermediary platform that attracts multiple NGO and investor resources, has bases in many communities, and supports learning processes. The network is strengthened when mutual relations are complementary and based on trusts. Having a broad reach adds to market creation and inclusivity.

Offering a variety of renewable energy technologies

It is advised that these institutions offer a variety of renewable energy technologies, to target all consumer segments and enhance inclusivity. Moreover, technological choice should take into account local productive uses, benefitting development objectives as well as creating appropriate business opportunities. It is further advised to work with market-based approaches that lease out technologies or sell electricity to ensure maintenance services can be offered, benefitting sustainability of the interventions.

Stimulate awareness creation via local agents and informal relations

Stimulate promotion/marketing of the renewables throughout the niche, with focus on the village level. This can enhance engagement of the local agents with the positive mission of a renewable energy transition, stimulating them to take on more entrepreneurial opportunities and use their informal relations to spread awareness. This benefits market creation as well as feelings of ownership.

Promoting flexibility and self-reflectiveness of institutions

It is vital that the institutional structures are flexible and self-reflective. This allows the institutions to continuously evaluate performance of technologies, business cases, local agents and user needs and feedback. This is necessary to ensure technologies and business cases fit the varying localities, benefitting market development and providing livelihood benefits.

Stimulate social learning amongst local agents and users

Stimulate formalised social learning amongst local agents and users. When local agents across localities are united in person a few times per year, experiences can be shared and they can get inspired by each other (working with local champions seems a viable option). Setting up a safe space allows users to freely express opinions, and they can be stimulated to think about entrepreneurial opportunities that renewable energy brings.

Foster management and business skills of local institutions
It is important that first-level institutions possess both management and business skills to facilitate niche development as well as participatory learning processes. Business skills are necessary to ensure financial independence and sustainability of technologies on the long term. Management skills allow constant evaluation and stimulation of learning amongst and within experiments, engaging with locals and ensuring inclusivity and feelings of ownership

7.4. The role of NGOs in stimulating appropriate institutional structures

This research confirms previous literature on the important role NGOs play in supporting newly-created institutional structures in pushing energy transitions in remote developing areas (Hansen & Nygaard, 2013; Pedersen et al., 2017; Ramos-Mejía et al., 2018; van Welie & Romijn, 2018) At the same time, the case study has shown that local institutions should prevent becoming completely dependent on donor money, which is especially the case for the social enterprise. This reiterates the importance of creating viable for-profit business models, which can use donor money to make initial risky investments but are able to sustain themselves independently.

By the same token, the findings in this research do not support the common critique that NGOs take too much of a short-term project focus, prohibiting long-term niche learning and coordination amongst a large body of stakeholders (Marquardt et al., 2016; Kamp & vanHeule, 2015). The case demonstrates that even when a national government commits itself to the renewable energy transition, international NGOs are the ones that unite to create the newly-formed institutional structures and make long-term commitments to niche development. Their long-term involvement is highly important in supporting local actors to initiate transitions (also argued by Pedersen et al., 2017). NGOs should encourage the build-up of institutions and improve their functional performance over time to enhance the uptake of renewable energy technologies (Tigabu et al., 2017). The case study illustrates that putting an institution in the hand of locals does not mean that it automatically instigates continuous, participatory learning and inclusivity. Newly-formed institutions often need time before management skills are sufficiently developed. With respect to this, donors have most experience in promoting capacity building and local empowerment.

Then how can NGOs best stimulate the creation of appropriate institutional structures as outlined in the previous section? Findings from the case emphasise the importance of seeing the local institutions as a platform, in which various NGOs can bundle expertise and monetary resources. This highlights the benefit of a multi-actor programme, by prohibiting single NGOs to pursue their own top-down objectives (Byrne, 2011). As argued by Tigabu et al. (2017), NGOs should mainly nurture positive interactions amongst local institutions. With their extensive knowledge on bottom-up development techniques, the case demonstrates how NGOs can help local institutions in developing management skills to pursue participatory techniques such as social learning (as also discussed by Wheeler et al., 2005). The emphasis should be on helping, not taking over such management responsibilities of the local institutions. As also argued by Byrne (2011), when renewable energy niches contain a variety of local institutional structures that interact meaningfully with each other, the local population, and international actors over a long time, learning can be generated that can substantially contribute to successful renewable energy transitions in remote developing contexts.

Chapter 8: Conclusion

This thesis has addressed the practically and theoretically relevant question of how newly-formed institutional structures can contribute to local societal embedding of renewable energy niche experiments in remote developing contexts. This question was answered through the lens of a case study of a multi-actor renewable energy transition programme on a remote island in east Indonesia. The roles of three newly-formed institutional structures were analysed - a cooperative, social enterprise, and private service company – that offer a variety of renewables including solar home systems, solar lanterns, micro-hydro energy and biogas. The analysis was guided by an innovative framework for analysis, including insights from strategic niche management and learning-based development approaches.

This thesis provides the novel insight that in remote developing contexts, newly-formed institutional structures primarily contribute to local societal embedding of renewable energy niche experiments by forming a complementary, trust-based institutional network. This network consists of various regional institutions that work with local agents across communities. The network can be regarded as an 'intermediary platform'; connecting multiple NGOs with a large number of localities, ensuring global knowledge and resources fit with particular localities across the niche. Regional institutions can be trained to provide the much-needed maintenance services on renewable energy technologies, whilst local agents can raise awareness for technologies in remote localities. The complementary network further enables market creation that targets various consumer segments to enhance inclusivity, by offering a range of technologies through different institutional structures. Such market creation proves crucial for sustainability of interventions, to overcome financial dependency on donors.

However, findings revealed that institutional structures are often faced with a trade-off between contributing to niche development and local participation. Although regional institutional structures (the private service company and social enterprise) can include more localities in the niche, they struggle to stimulate proper community-level learning. Local agents are often viewed as mere technology distribution points, whilst their key position in collecting input from the local population is not utilised. With its local presence in one community, the cooperative is better able to engage with the local population. The latter case shows it is a mistake to view renewables as inherently top-down technologies, as optimising their social configuration in remote developing contexts requires long-term bottom-up learning processes. Consequently, it is argued that the local institutions should have strong management capabilities, to stimulate processes of social learning amongst local agents and between users. Such horizontal connections within the network are often lacking in remote areas, yet provide opportunities to enhance local feelings of ownership and participation. Findings show that NGOs play an important role in supporting the newly-formed institutions with their extensive knowledge of bottom-up strategies, on the conditions that they do not take over management responsibilities and their involvement is long-term.

Theoretically, the deployed synthesis of literature on strategic niche management and learning-based development approaches advances transition theories' applicability to

developing countries. Although their complementariness has been indicated previously, this research was the first to actually apply both frameworks. The combination proved effective to unravel complex transition processes in developing countries, as reflected in the findings. The learning-based development framework made the analysis receptive to local institutions' impact on inclusivity, local consultation and empowerment. A sole strategic niche management analysis would not have revealed low feelings of ownership amongst the local population, with the associated negative consequences for societal embedding of the niche experiments. By applying the strategic niche management framework, it was possible to analyse how (learning) connections between experiments contribute to local embedding of the renewables, indicating its substantial relevance for application in developing countries. Additionally, this research added the concept of market creation to the strategic niche management framework. The findings show that especially in remote developing areas, a specific focus on the stimulation of business opportunities that sell and use renewables is of paramount importance for the long-term sustainability of the energy niche.

Thus, the important contributions of this work are twofold. First, findings from the empirical case study shed light on the importance of critically evaluating the role of newly-formed institutional structures in reconciling environmental goals for renewable uptake and socio-economic development goals to reduce poverty of transition programmes in remote developing contexts. Whilst many studies put the role of NGOs on the foreground, this research emphasises the importance of evaluating the role of newly-formed institutional structures themselves. They are the ones that will stay in the long-term, and hence play the most important role in local societal embedding of the renewable energy niche. Moreover, the combined framework of strategic niche management and learning-based development approaches was able to holistically conceptualise local societal embedding of renewable energy niches, incorporating environmental, economic and social sustainability. Its application to other programmes in similar contexts could further contribute to the framework's development as well as point out useful avenues for better institutional practice.

Hence, further research is needed. This thesis was limited to one case study. Although multiple institutional structures offering various renewable energy technologies were studied and findings have been compared to prior research, both practice and theory would benefit from the framework's application to other cases. In doing so, several considerations should be taken into account. First, the concept of social learning could be more specifically integrated in the analysis, to evaluate what types of horizontal connections between local agents and users are effective and feasible in remote areas. Second, studies should assess whether relations between complementary institutional structures are as trust-based and harmonic, amplifying contributions to successful societal embedding, as was found for this case study. Third, longitudinal studies are needed to assess long-term development and sustainability of institutional structures, especially after NGOs leave the renewable energy niche. Moreover, the long-term impacts, specifically regarding power imbalances and inclusivity, of the market-based institutional structures and technologies are unclear, providing avenues for future research. Herewith, further research could enrich generalisations on what the 'right' institutional structures are, that benefit both niche development and inclusive empowerment. Such insights are highly needed to ensure it are the most vulnerable who can benefit from renewables in the long-term. This thesis showed that newly-formed

institutional structures are put in the chief position to connect international resources with the most vulnerable people in remote areas, and hence who have significant potential to address the two great challenges of the 21st century at the same time: *'the battle against poverty and the management of climate change'*.

(Ban Ki-moon, former Secretary-General of the United Nations)

References

Ardiansyah, F., Gunningham, N., & Drahos, P. (2012). An environmental perspective on energy development in Indonesia. In: Caballero-Anthony, M., Chang, Y., Putra, N.A. (2012). *Energy and non-traditional security (NTS) in Asia*, 89-117. Berlin: Springer.

Barnes, D. F., & Floor, W. M. (1996). Rural Energy in Developing Countries: A Challenge for Economic Development1. *Annual review of energy and the environment*, *21*.

Berkhout, F., Verbong, G., Wieczorek, A. J., Raven, R., Lebel, L., & Bai, X. (2010). Sustainability experiments in Asia: innovations shaping alternative development pathways?. *Environmental science & policy*, *13*(4), 261-271.

Berkhout, F., Wieczorek, A. J., & Raven, R. (2017). Avoiding environmental convergence: a possible role for sustainability experiments in latecomer countries?. *Institutions and Economies*, 367-385.

Blum, N. U., Bening, C. R., & Schmidt, T. S. (2015). An analysis of remote electric mini-grids in Laos using the Technological Innovation Systems approach. *Technological Forecasting and Social Change*, *95*, 218-233.

Booth, D. (2011). Aid, institutions and governance: What have we learned?. *Development Policy Review*, *29*, 5-26.

Brass, J. N., Carley, S., MacLean, L. M., & Baldwin, E. (2012). Power for development: A review of distributed generation projects in the developing world. *Annual Review of Environment and Resources*, *37*, 107-136.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology*, *3*(2), 77-101.

Bruges, M., & Smith, W. (2009). Improving utilisation of Māori land: Challenges and successes in the application of a participatory approach. *Kōtuitui: New Zealand Journal of Social Sciences Online*, *4*(3), 205-220.

Byrne, R. P. (2011). *Learning drivers: rural electrification regime building in Kenya and Tanzania* (Doctoral dissertation, University of Sussex).

Campbell, B., & Sallis, P. (2013). Low-carbon yak cheese: transition to biogas in a Himalayan socio-technical niche. *Interface focus*, *3*(1), 20120052.

Caniëls, M. C., & Romijn, H. A. (2008). Actor networks in strategic niche management: insights from social network theory. *Futures*, *40*(7), 613-629.

Chang, Y. C., & Chen, M. H. (2004). Comparing approaches to systems of innovation: the knowledge perspective. *Technology in Society*, *26*(1), 17-37.

Chelminski, K. (2015). The Political Economy of Energy Access and Sustainable Energy Transitions in Indonesia. *L'Europe en Formation*, (4), 146-165.

CIRCLE Indonesia. (2018). *Project Final Evaluation Report. Investing in Renewable Energy for Rural, Remote Communities (TERANG) – Hivos SEA*. Jakarta: Hivos.

Coenen, L., Raven, R., & Verbong, G. (2010). Local niche experimentation in energy transitions: A theoretical and empirical exploration of proximity advantages and disadvantages. *Technology in Society*, *32*(4), 295-302.

Collins, K., & Ison, R. (2009). Jumping off Arnstein's ladder: social learning as a new policy paradigm for climate change adaptation. *Environmental Policy and Governance*, *19*(6), 358-373.

Damuri, Y. R., & Atje, R. (2012). Investment incentives for renewable energy: case study of Indonesia. *Trade Knowledge Network*.

Douthwaite, M. B. (2002). *Enabling innovation: A practical guide to understanding and fostering technological change*. London: Zed Books.

Drinkwaard, W., Kirkels, A., & Romijn, H. (2010). A learning-based approach to understanding success in rural electrification: Insights from Micro Hydro projects in Bolivia. *Energy for Sustainable Development*, *14*(3), 232-237.

Eswarlal, V. K., Vasudevan, G., Dey, P. K., & Vasudevan, P. (2014). Role of community acceptance in sustainable bioenergy projects in India. *Energy Policy*, *73*, 333-343.

Fuenfschilling, L., & Truffer, B. (2014). The structuration of socio-technical regimes—Conceptual foundations from institutional theory. *Research Policy*, *43*(4), 772-791.

Geels, F. W., Berkhout, F., & van Vuuren, D. P. (2016). Bridging analytical approaches for low-carbon transitions. *Nature Climate Change*, *6*(6), 576.

Geels, F. W., & Schot, J. (2007). Typology of sociotechnical transition pathways. *Research policy*, *36*(3), 399-417.

Guerreiro, S., & Botetzagias, I. (2018). Empowering communities–the role of intermediary organisations in community renewable energy projects in Indonesia. *Local Environment*, *23*(2), 158-177.

Gunningham, N. (2013). Managing the energy trilemma: The case of Indonesia. *Energy Policy*, *54*, 184-193.

Hansen, U. E., & Nygaard, I. (2013). Transnational linkages and sustainable transitions in emerging countries: exploring the role of donor interventions in niche development. *Environmental Innovation and Societal Transitions*, *8*, 1-19.

Hansen, U. E., & Nygaard, I. (2014). Sustainable energy transitions in emerging economies: The formation of a palm oil biomass waste-to-energy niche in Malaysia 1990–2011. *Energy Policy*, *66*, 666-676.

Hansen, U. E., Nygaard, I., Romijn, H., Wieczorek, A., Kamp, L. M., & Klerkx, L. (2018). Sustainability transitions in developing countries: Stocktaking, new contributions and a research agenda. *Environmental Science & Policy, 84,* 198-203.

Hennink, M., Hutter, I., & Bailey, A. (2010). *Qualitative research methods*. Thousand Oaks, California: Sage.

Hivos. (2015). *A Case Study of the Multi-Actor Sumba Iconic Island Initiative.* Jakarta: Hivos. Retrieved January 12, 2018 from https://hivos.org/case-study-multi-actor-sumba-iconic-island-initiative.

International Energy Agency (IEA). (2017). Energy Access Outlook 2017: From poverty to prosperity. *Energy Procedia*, *94.* https://doi.org/10.1787/9789264285569-en.

Kamp, L. M., & Vanheule, L. F. (2015). Review of the small wind turbine sector in Kenya: Status and bottlenecks for growth. *Renewable and Sustainable Energy Reviews*, *49*, 470-480.

Kebede, K. Y., Mitsufuji, T., & Choi, E. K. (2014). Looking for innovation system builders: A case of Solar Energy Foundation in Ethiopia. *African Journal of Science, Technology, Innovation and Development*, *6*(4), 289-300.

Kemp, R., Schot, J., & Hoogma, R. (1998). Regime shifts to sustainability through processes of niche formation: the approach of strategic niche management. *Technology analysis & strategic management*, *10*(2), 175-198.

Korten, D. C. (1980). Community organization and rural development: A learning process approach. *Public administration review*, 480-511.

Kruckenberg, L. J. (2015). Renewable energy partnerships in development cooperation: Towards a relational understanding of technical assistance. *Energy Policy*, *77*, 11-20.

Langford, G., Adams, P., Richter, M. M. (2017). *Landscape –Lifescape: A context and risk analysis: for nine districts in Lombok, South Sulawesi & Sumba Island.* Jakarta: Hivos. Retrieved May 2, 2018 from http://en.sumbaiconicisland.org/download/.

Lawrence, T., Suddaby, R., & Leca, B. (2011). Institutional work: Refocusing institutional studies of organization. *Journal of management inquiry*, *20*(1), 52-58.

Lundry, C. (2009). *Separatism and state cohesion in Eastern Indonesia*. Tempe, Arizona: Arizona State University.

Marquardt, J., Steinbacher, K., & Schreurs, M. (2016). Driving force or forced transition?: The role of development cooperation in promoting energy transitions in the Philippines and Morocco. *Journal of Cleaner Production*, *128*, 22-33.

Martinot, E., Chaurey, A., Lew, D., Moreira, J. R., & Wamukonya, N. (2002). Renewable energy markets in developing countries. *Annual review of energy and the environment*, *27*(1), 309-348.

Minh, T. T., Friederichsen, R., Neef, A., & Hoffmann, V. (2014). Niche action and system harmonization for institutional change: prospects for demand-driven agricultural extension in Vietnam. *Journal of Rural Studies*, *36*, 273-284.

Mohamad, Z. F., Idris, N., & Mamat, Z. (2012). Role of religious communities in enhancing transition experiments: a localised strategy for sustainable solid waste management in Malaysia. *Sustainability science*, *7*(2), 237-251.

Mourik, R., & Raven, R. (2006). A Practitioner's View on Strategic niche Management. *Energy Research Centre of the Netherlands Report, ECN-E–06-039*.

Noble, H., & Smith, J. (2015). Issues of validity and reliability in qualitative research. *Evidence-Based Nursing*, *18*(2), 34-35.

Opazo, J. (2014). *The politics of system innovation for emerging technologies: understanding the uptake of off-grid renewable electricity in rural Chile* (Doctoral dissertation, University of Sussex).

Ortiz, W., Dienst, C., & Terrapon-Pfaff, J. (2012). Introducing modern energy services into developing countries: the role of local community socio-economic structures. *Sustainability*, *4*(3), 341-358.

Osunmuyiwa, O., Biermann, F., & Kalfagianni, A. (2018). Applying the multi-level perspective on socio-technical transitions to rentier states: the case of renewable energy transitions in Nigeria. *Journal of Environmental Policy & Planning*, *20*(2), 143-156.

Oyake-Ombis, L., van Vliet, B. J., & Mol, A. P. (2015). Managing plastic waste in East Africa: Niche innovations in plastic production and solid waste. *Habitat International*, *48*, 188-197.

Pedersen, M. B., Nygaard, I., & Wehrmeyer, W. (2017). *Rural electrification through private models: the case of solar-powered mini-grid development in Kenya: Exploring the hybrid nature of private business models and the interplay between new players and existing structures in the Kenyan rural electrification regime.* (Doctoral dissertation, Technical University of Denmark).

PwC. (2013). *Power in Indonesia: Investment and Taxation Guide. 2nd edition*. PWC: Jakarta.

Ramos-Mejía, M., Franco-Garcia, M. L., & Jauregui-Becker, J. M. (2018). Sustainability transitions in the developing world: Challenges of socio-technical transformations unfolding in contexts of poverty. *Environmental science & policy*, *84*, 217-223.

Reber, T., Burman, K., & Hirsch, B. (2016). *Sustainable Energy for Remote Indonesian Grids: Strategies to Accelerate Nationwide Deployment*. Golden, Colorado: National Renewable Energy Laboratory.

Rehman, I. H., Kar, A., Raven, R., Singh, D., Tiwari, J., Jha, R., Sinha, P.K., & Mirza, A. (2010). Rural energy transitions in developing countries: a case of the Uttam Urja initiative in India. *Environmental science & policy*, *13*(4), 303-311.

Rolffs, P., Ockwell, D., & Byrne, R. (2015). Beyond technology and finance: pay-as-you-go sustainable energy access and theories of social change. *Environment and Planning, 47*(12), 2609-2627.

Romijn, H. A., & Caniëls, M. C. (2011). The Jatropha biofuels sector in Tanzania 2005–2009: evolution towards sustainability?. *Research Policy*, *40*(4), 618-636.

Romijn, H. A., Raven, R., & de Visser, I. (2010). Biomass energy experiments in rural India: Insights from learning-based development approaches and lessons for Strategic Niche Management. *Environmental Science & Policy*, *13*(4), 326-338.

Salvini, G., Van Paassen, A., Ligtenberg, A., Carrero, G. C., & Bregt, A. K. (2016). A role-playing game as a tool to facilitate social learning and collective action towards Climate Smart Agriculture: Lessons learned from Apuí, Brazil. *Environmental Science & Policy*, *63*, 113-121.

Schot, J., & Geels, F.W. (2008). Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy. *Technology Analysis & Strategic Management, 20*(5), 537-554.

Sengers, F., Wieczorek, A. J., & Raven, R. (2016). Experimenting for sustainability transitions: A systematic literature review. *Technological Forecasting and Social Change*.

Slingerland, M., & Schut, M. (2014). Jatropha developments in Mozambique: analysis of structural conditions influencing niche-regime interactions. *Sustainability*, *6*(11), 7541-7563.

Sovacool, B. K. (2013). A qualitative factor analysis of renewable energy and Sustainable Energy for All (SE4ALL) in the Asia-Pacific. *Energy Policy*, *59*, 393-403.

Sovacool, B. K., Bazilian, M., & Toman, M. (2016). Paradigms and poverty in global energy policy: research needs for achieving universal energy access. *Environmental Research Letters*, *11*(6), 064014.

Späth, P., & Rohracher, H. (2012). Local demonstrations for global transitions—Dynamics across governance levels fostering socio-technical regime change towards sustainability. *European Planning Studies*, *20*(3), 461-479.

Tigabu, A., Berkhout, F., & van Beukering, P. (2017). Development aid and the diffusion of technology: Improved cookstoves in Kenya and Rwanda. *Energy Policy*, *102*, 593-601.

Ulsrud, K., Winther, T., Palit, D., & Rohracher, H. (2015). Village-level solar power in Africa: accelerating access to electricity services through a socio-technical design in Kenya. *Energy Research & Social Science*, *5*, 34-44.

Uphoff, N., Esman, M. J., & Krishna, A. (1998). *Reasons for success: Learning from instructive experiences in rural development*. West Hartford, Connecticut: Kumarian Press.

Verschuren, P., & Doorewaard, H. (2010). *Designing a research project (Vol. 2)*. The Hague: Eleven International Publishing.

van Welie, M. J., & Romijn, H. A. (2018). NGOs fostering transitions towards sustainable urban sanitation in low-income countries: Insights from Transition Management and Development Studies. *Environmental Science & Policy*, *84*, 250-260.

Wheeler, D., McKague, K., Thomson, J., Davies, R., Medalye, J., & Prada, M. (2005). Creating sustainable local enterprise networks. *MIT Sloan Management Review*, *47*(1), 33.

Wieczorek, A. J. (2018). Sustainability transitions in developing countries: Major insights and their implications for research and policy. *Environmental Science & Policy*, *84*, 204-216.

Yin, R. K. (2009). *Case study research: Design and methods (applied social research methods).* Thousand Oaks, California: Sage.

Appendix A: Expert interviews

Table I. Expert interviews.

	Name	Organisation	Function	Gender	Time & Place
1	Sandra Winarsa	NGO Hivos Southeast Asia	Project Manager Green Energy	Female	Jakarta, 15-03-2018 & 11-05-2018
2	Gita Meidita	NGO Hivos Southeast Asia	Design, Monitoring, Evaluation and Learning Officer	Female	Jakarta, 15-03-2018
3	Peter Konings	NGO Winrock International	Hired as Consultant, engaged in training RESCO staff between September 2016 and January 2018	Male	Skype, 19-03-2018
4	Sapto Nugroho	NGO IBEKA	Managing Director	Male	Kamanggih (Sumba), 24-03-2018
5	Dedi Haning	NGO Hivos Southeast Asia	SII Stakeholder Engagement Manager	Male	Waingapu (Sumba), 27-03-2018
6	Adi Laksono	NGO IBEKA	Monitoring & Evaluation Manager	Male	Waingapu (Sumba), 28-03-2018
7	Mr. Alan	NGO Winrock International	Field Officer (previous function)	Male	Waingapu (Sumba), 03-04-2018
8	Rita Kefi	NGO Hivos Southeast Asia	SII Community Engagement & Gender Field Officer	Female	Waingapu (Sumba), 06-04-2018
9	Gus Firman	NGO Hivos Southeast Asia	SII Monitoring & Evaluation Manager	Male	Waingapu (Sumba), 08-04-2018
10	Rudi Nadapdap	NGO Hivos Southeast Asia	SII Field Office Manager	Male	Waingapu (Sumba), 10-04-2018
11	Stewart Caine	Investor Village Infrastructure Angels	Managing Director	Male	Skype, 18-04-2018
12	Laily Himayati	NGO Hivos Southeast Asia	Stakeholder Engagement Manager	Female	Skype, 28-04-2018
13	Ani Wiyanti	Government of Indonesia, Ministry of Energy and Mineral Resources	Deputy Director of Investment and Cooperation of Various New and Renewable Energy	Female	E-mail, 11-06-2018

Appendix B: Interview topic lists

The following four general question lists have been used to interview and conduct FGD with 1) experts, 2) first-level institutions & second-level institutions, 3) users & non-users. It should be noted that the question lists were adjusted to target the specific audience (in relation to technology received) and were only used as a guide. All question lists included the following introduction and informed consent request:

Hello, my name is Carlijn Freutel. I am a student from the Netherlands, studying Sustainable Development. I am in Indonesia to conduct research on the Sumba Iconic Island programme. This interview will be used to write a master thesis for my studies. Before we start the interview, I would like to ask you consent for recording this interview. All the data will be treated anonymously and confidentially, and you are able to stop at any point throughout the interview. Are you willing to be interviewed?

Appendix B1. Interview question lists experts

Introduction questions

- Age
- Gender
- Nationality
- Educational level
- Job

Opening questions

- What is the main aim of SII?
- Which projects has your organisation initiated on Sumba?
- What is your role within these projects/SII?
- How are the projects funded?

Intervention methods

Technology

- Which technologies has your organisation installed on Sumba?
    - *Types, amount, place*
- Why have these technologies been chosen?
    - *Reasons, input from locals, alignment with local needs, feasibility, building on existing capabilities, using locally available resources*

Implementation

- Who has been responsible for implementing these technologies?
    - *NGOs, government, local CSOs, local populations*
- How have organisational processes within and between implementing organisations been going?
    - *Number of executive managers, openness to change and feedback, level of bureaucracy*
- How has the process of implementation been going?
    - *Obstacles, opportunities, communication, knowledge sharing, engagement with local populations, flexibility to change, adaption to local circumstances*

Adoption of technologies

- What is the current state of the adoption of the technologies?
    - *Management, users, challenges, opportunities, promotion of the technologies*
- How are the interventions monitored?
    - *Frequency, quality, comprehensiveness*
- Are you considering to distribute other technologies?

Inclusivity and sustainability of interventions

Inclusiveness & participation locals

- To what extent does your intervention aim to be inclusive?
    - *Technology accessible for all community members, participatory decision-making, taking into account power structures and culture, demand-driven*
- Does the intervention empower the local population, and how?
    - *Capacity building activities, participation, co-creation of knowledge, local ownership*

Connections between experiments

- Do the different interventions connect to each other, and how?
    - *types of interaction, shared expectations, types of learning*

Sustainability and local embeddedness

- How do you ensure sustainability of the interventions after donor support stops?
    - *Importance local embedding, newly-formed institutional structures, new market opportunities, network creation between interventions*
- How do you believe the interventions can become locally embedded?

Newly-formed institutional structures

Relation to existing local institutions

- How did your intervention connect to local institutional structures?
    - *Choice of distribution channel, partnerships with existing institutions, creating new institution*
- Why these local institutions?

Newly-formed institutions & local embedding

- Which institutional structures have been created within SII and for what reason?
    - *Types, relation to existing local institutions, reasons, input from locals*
- What is your view on the role of these newly-formed institutional structures?
    - *Positive/negative impacts, challenges*
- Do you believe these newly-formed institutions are important for local embedding of the interventions? How and why?

Learning-based participatory processes and newly-formed institutional structures

- In creating the new institutional structure, did you take into account local capacity and available resources?
    - *People involved, their capacity, local available infrastructure, fit with local economic activities, fit with natural environment, capacity building activities*
- How is the newly-formed institutional structure managed and why in this way?
    - *Rationale for management, number of executive managers, openness to change, level of bureaucracy, knowledge sharing (internal and external), communication with implementing organisation, engagement with local population, monitoring*

- How does the new institution engage with the local population and their culture?
    - *Power structures, habits, norms and values, religions, people's mindset*
- Do you believe the new institutions are important for making the intervention inclusive & participatory?

Niche development and role newly-formed institutional structures

- Do different institutions connect to each other and how?
    - *Types of institutions that connect, interaction, knowledge sharing, contribution to niche development*
- Do you believe the different institutions have similar expectations of the renewable energy interventions?
    - *Voicing of expectations, providing direction*
- Are there learning processes apparent between institutions/experiments?
    - *Technical optimisation, product maintenance, social optimisation*
- What is the role of new institutions in creating a viable local market for renewable energy?
    - *Stimulating local entrepreneurship, appropriate business models*
- Do you believe connections between interventions are important for making SII locally embedded and hence sustainable on the long-term?

Closing questions

- How do you think SII has benefited the local Sumbanese population so far?
- What are the next steps your organisation will take to enhance local societal embedding of the interventions within SII?
    - *Importance newly-formed institutional structures*
- How do you think electrification can be further enhanced on Sumba?
- What are lessons learned from the programme so far? And for other places around the world?

Appendix B2. Interview question lists local institutions. Questions with an asterisk were only asked to the first-level institutions (cooperative Kamanggih, social YRE and private service company RESCO).

Introduction questions

- Age
- Gender
- Nationality
- Educational level
- Job

Opening questions

- When was your organisation created? Specifically for the SII programme?
- What does your organisation do?
- What is your role in the organisation? How long have you been working here?
- What is the reason that your organisation takes part in SII?
- Which technologies has the organisation implemented?
- (Which other technologies are offered in the environment?)

Learning-based participatory processes

Management

- How is the staff of the organisation recruited?*
    - *Local population, geographical spread, gender, educational level*
- How is the staff of the organisation trained?*
- How has implementation of the technologies been going?
    - *Obstacles, opportunities, adoption by locals, adaptation to changing circumstances, flexibility, openness to change*
- What is the role of this organisation in promoting the technology?
    - *Stimulation of adoption and participation of locals, awareness creation, influential role in society*
- Are you able to manage your responsibilities? Any problems?
    - *E.g. bookkeeping, commitments to RESCO, getting customers.*
- How is monitoring of the experiments arranged?*
    - *Frequency, quality, comprehensiveness, responsibility*

Technological fit with locality

- Do you think the technologies offered are wanted by the local population?
    - *Addressing local needs, input from local population, benefits to population, norms and values, power structures*
- Does the technology use locally available resources?
    - *Fit with environment, fit with capacities of people, fit with economy, fit with infrastructure*
- How is it to find customers? Are they able to pay?
- (How many technologies have you leased out?)
- Have there been any problems with the technology so far? What do you do in case of problems?

Community-level learning

- How does the organisation communicate with various stakeholders? How often?

    - *Knowledge exchange with other institutions and local population, input from local population*
- Do you take feedback into account from local agents/users?
- Is the local population able to share their knowledge and experience on the technologies with first- and/or second-level institutions?
- Do you provide any training to the local population/second-level institutions? Who is invited?
    - *Capacity building training, socialisation*

Principles of participation & adoption of technology

- Are all people in the communities able to access the technologies? What is the role of the institution in this?
    - *Accessibility, involvement, adoption, local power structures*
- Do you feel empowered by working for this institution?
- How does the institution benefit your household?
- Do you believe the technologies empower the local population, and how?
- Are local community members involved in decision-making processes?
- Do you believe local community members and the new institutions have the same views and goals for the new technologies?
    - *mutual agreements, openness to create shared goals, similar views on interventions*

Niche development processes

Connections with other institutions

- To which other institutions do you connect? How? And how frequent?
    - *type of actors, type of connections, types of interactions, cooperation, frequency*
- How have these interactions and cooperation with other institutions been going?
    - *Obstacles, opportunities, knowledge sharing, enhanced resources or capabilities, contribution to the niche*
- Do you think such connections are useful/would be useful?
- What do you think working with the second-level organisation to distribute technologies?*
- How is the management of the second-level institutions going? What needs to be improved?*
- How is the relation to NGOs? How often do you communicate?*

Learning within the niche

- Do you connect to other institutions to enhance learning within SII? To which and how?
    - *Types of other institutions, technical optimisation, infrastructure for dissemination, new innovation, production and maintenance, social optimisation, knowledge sharing*
- Does learning take place between other institutions that you know of? Do you try to stimulate this amongst second-level institutions?*
- Do you think learning exchanges are/would be useful?
- Are you able to provide feedback to other institutions or NGOs?

Convergence of expectations

- What is the long-term goal of your organisation?
- What are your expectations of the experiment?
- Are you able to voice these expectations? To who and how?
- Does this align with those of other actors, in the community and SII in general?

Market development

- Do you think SII and your organisation created or will create a market for renewable energy on Sumba? How?

    - *Stimulation of local entrepreneurship, income-generating, addressing locals' needs*
- Does your institution contribute to market development? How?
- Is it easy to find customers? Where do they come from?
- Would your organisation like to sell more technologies in the future?

Closing questions

- Do you think your organisation contributes to local embedding of the interventions? How?
- How do you fund your activities? And for future projects?*
- How can SII and your organisation be sustainable on the long term?
- What do you think are aspects to improve about your organisation or the programme to make it more sustainable and locally embedded?
    - *Different technologies, management structures, learning*

Appendix B3. Interview/FGD question lists for users and non-users. Opening questions differed, and questions with an asterisk were only asked to users.

Introduction questions

- Age
- Gender
- Educational level
- Job
- Location + how far from distribution point

Opening questions - users

- Which (renewable) energy technologies do you or your household use? Since when?
- How did you know about the technology?
    - *Promotion by institutions, awareness creation*
- Did you immediately want to get the technology? Why or why not?
- How did you acquire the technology?

Opening questions – non-users

- Are you aware of the renewable energy technologies offered in your community?
    - *Promotion by institutions, awareness creation*
- What is the reason you do not have this technology?
- Would you like to access this technology? Why or why not?
- Did any institutions every offer you the technology? Which?
- Do you have any access to other (renewable) energy technologies?

Learning-based participatory processes

Technological fit with locality

- Is this technology useful for your household? Why and how?
    - *Addressing local needs, benefits to local population*
- Did you ever have an opportunity to indicate to the NGOs or other institutions what renewable energy technology you needed?
- Do you want to pay for using the technology? If applicable, do you think the payments are fair?
- How do you pay? Do you always pay on time?*

Adoption of and access to technology

- Is it easy for you to get access to the technology?
    - *Accessibility, local power structures, informal relations*
- Via which institution do you access the technology? Did you already engage with this institution before? What do you think of accessing it via this way?
    - *Fit with environment, fit with economy, fit with infrastructure*
- How often do you engage with this institution?
- What is easy for you to adopt the technology? Why or why not?
    - *Fit with capacities of people, fit with environment*

Learning about technologies

- Did you receive any training to adopt the technology? By whom? And how useful was this training?
    - *Training in adoption, in management techniques and technical skills, socialization training*

- Did you ever receive any other training?
- Do you ever talk to other users or institutions about the technologies? Do you share ideas?*
- Are you able to engage with the institutions (first- and second-level institutions) to share any concerns, complaints or feedback you have?*
    - *Input from local population, feedback, exchanging views, communication from institutions, ability to share knowledge*

Participation and ownership

- Do you have any input in decision-making processes in the cooperative/RESCO/school/agents? How and what do you think of this?*
    - *Inclusivity and participatory decision-making processes*
- Do you have any agreements with the institutions (first- and second-level institutions)? If yes, what kind and what do you think of this?*
    - *Mutual agreements, ability for input from local population*
- Do you feel responsible for letting the project succeed?*
    - *Sense of local ownership, responsibility, always paying fees*
- Do you believe the technologies are inclusive for everyone?
    - *Local power structures, culture, gender*
- Do you think the newly-formed institution enhances inclusiveness?
- How can inclusiveness be enhanced according to you?

Livelihood impacts

- How does the technology impact you and your family? (benefits)
    - *Income, new business opportunities, security, educational, everyone in the household, extra time other activities*
- And how does it impact the community?
- How can the benefits be enhanced?

Closing questions

Overall opinion newly-formed institution & future opportunities

- Do you want to continue acquiring the technology in the future? Via this institution?
- How can the institution improve providing the technologies? Or are other ways to providing access needed?
- Are there any other technologies you want to have in the future? Why and how?
- How would you like to access these technologies?
- Would you be interested in closer contact with other users or institutions?*

Appendix C: NGO reports

The following study has been used for qualitative background data on the SII programme and impacts:

- CIRCLE Indonesia. (2018). *Project Final Evaluation Report. Investing in Renewable Energy for Rural, Remote Communities (TERANG) – Hivos SEA*. Jakarta: Hivos.

The following reports have been used for quantitative background information on the SII programme and the island of Sumba:

- Hivos. (2015). *A Case Study of the Multi-Actor Sumba Iconic Island Initiative.* Jakarta: Hivos. Retrieved January 12, 2018 from https://hivos.org/case-study-multi-actor-sumba-iconic-island-initiative.
- Langford, G., Adams, P., Richter, M. M. (2017). *Landscape – Lifescape: A context and risk analysis: for nine districts in Lombok, South Sulawesi & Sumba Island.* Jakarta: Hivos. Retrieved May 2, 2018 from http://en.sumbaiconicisland.org/download/.

Appendix D: Codebook

Niche development processes

Actor network creation

- Actor network composition
  - Network composition – roles actors
  - Network composition – resources actors
  - Network composition – decision-making power actors
- Interaction and cooperation
  - Exchanges of experiences between actors
  - Frequency of interaction
  - Openness to share experiences
  - Informal relations
  - Power relations
  - Dependency NGOs
  - Connecting role
- Quality of the network

Convergence of expectations

- Voicing of expectations
- Shaping of expectations
  - Negotiations of expectations
  - Adoption of similar expectations
- Providing direction for innovation
- Trust

Niche-level learning

- Learning on technical optimisation
  - Technical design
  - Technical complementariness
- Learning on social optimisation
  - User preferences
  - Overcoming user barriers to adoption
  - Learning on production and maintenance
- Co-creation of knowledge
  - Use of success stories
  - Knowledge sharing between institutions

Market creation

- New appropriate business models
  - Promotion of technologies
  - Payments in crops
  - Strategic place
  - Income-generating
  - Critique business models
- Stimulation of local entrepreneurship
  - Business that use energy
  - Business that distribute renewable energy technologies
  - Entrepreneurial mind-set
- Evaluating business models
  - Prices
  - Strategic location
  - Charging frequency users
  - Usage of technologies
  - Critique distribution systems

Learning-based participative approaches

Project design & management

- Local resource mobilization
  - Using locally available resources
  - Using existing capabilities
  - Selection of local agents
- Local fit of technologies
  - Input local population
  - Addressing local needs
  - Quality
  - Fit with local culture and environment
- Organisational structure
  - Openness to change
  - Fit with innovation
- Flexibility

Strong leadership

- Raising awareness
  - Stimulating adoption
  - Influential role in community
  - Mouth-to-mouth spread of information
- Communication and monitoring
  - Internal and external communication
  - Engagement with stakeholders
  - Communication with beneficiaries
  - Process monitoring
- Trust

Community-level learning

- Voicing of opinions
  - Consulting local population
  - Incorporating feedback
  - Ability to voice opinion
- Capacity building
  - Training management & technical skills
  - Training adoption technologies
  - Gender training
  - Socialisation

Local participation

- Inclusivity
  - Accessibility
  - Adoption patterns
  - Power structures
  - Willingness to pay
- Local ownership
  - Motivation to adopt innovation
  - Sense of local ownership
  - Sense of responsibility project success

Background information

Background information SII

- Initiation
- Actors involved
- Rationale of working with local institutions
- Ideas for future
- Information Sumba

Background information key stakeholders

- Hivos
- Winrock International
- Village Infrastructure Angels
- IBEKA
- Government

Background information newly-formed institutions

- RESCO
    - PV schools
    - Energy kiosk
    - Agro-processing agents
- YRE
    - Construction partner organisations
    - Bio-slurry distributors
- Cooperative Kamanggih