MASTER THESIS

Identification of Systemic Problems of Sumba Iconic Island,
A Renewable Energy Initiative

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Contents

LIST OF ACRONYMS

ADB	Asian Development Bank
IEA	International Energy Agency
KW	Kilo Watt
MEMR	Ministry of Energy and Mineral Resources
MW	Mega Watt
NGO	Non Governmental Organizations
PLN	PT. Perusahaan Listrik Negara (Persero)
SEHEN	*Super Ekstra Hemat Energi* [Super Low-cost Energy] - PLN's solar-powered lamp program

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ABSTRACT

This research identifies systemic problems in the implementation of Sumba Iconic Island, a pilot renewable energy island initiative in Indonesia. Since the inauguration of the project in 2010, Sumba Iconic Island had increased the electrification ratio from 24% to 42% in 2016. Yet, there remains a substantial gap between renewable energy potential and current implementation. In this context, the research aims to make a contribution. This research combines structural and functional analysis of innovation system approach. In particular, fulfillment of three systems functions most relevant to Sumba case is explored: entrepreneurial activities, knowledge development and diffusion, and mobilization of resources. The data are gathered through semi-structured interviews with key stakeholders.

The performance of 'entrepreneurial activities' function is evaluated at the level of weak, 'knowledge development and diffusion' function at at the level of moderate, and 'mobilization of resources' function at the level of weak. Further examination of the weakness of those system functions discovers specific systemic problems. Examples of systemic problems are: (i) Absence of feed-in-tariff and other expected government support for private sector, (ii) Insufficient frequency of continuous capacity building and awareness raising, and (iii) Insufficient capacity of public and private stakeholders to pool financial resources for the purpose of increasing the implementation. These findings indicate the urgent need to design an integrated systemic policy framework to address the problems in a more orchestrated manner.

Keywords: renewable energy, energy transition, innovation system, structural analysis, functional analysis

CHAPTER 1. INTRODUCTION

1. 1. Background

Access to energy service is deemed as an essential right to development. Energy access determines the level of productivity, health, education, safe water and communication services (Gaye, 2007). Despite the growth on global energy consumption the disparity between regions is clearly visible. Countries lacking energy access tend to rank low on Human Development Indicator (Bhattacharyya, 2012). The International Energy Agency pointed out that 1,3 billion people does not have access to modern energy services. From that number, more than 95% lives in sub-Saharan Africa or developing Asia and 84% in rural areas (IEA a, 2011). Many countries have experienced abundant barriers to improving access to modern energy services.

Although electrification access in Indonesia has been improving in recent years, it still remains at the level of 88% in 2015. The government set the target to increase rural electricity access and achieving 99% national electrification by 2025[1]. Currently, the majority of the Indonesian Islands' populations do not have access to electricity. Few that does still experiences irregular services and remain reliant on wood for fuel (Hivos a, 2012). The state-owned electricity company (PT. Perusahaan Listrik Negara) is planning the establishment of coal powered generators for larger islands and industrial hubs, but its capacity to provide low cost electricity to the smaller islands is limited.

The experiences of developing countries achieving near-universal electrification - such as China, Mexico and Thailand - shows that connecting the last 10 – 15% population are the most costly and time-consuming electrification endeavor (ADB a, 2016). As Indonesia is currently approaching the similar level of electricity, the undertakings to increase electrification should reach isolated or remote settlements which tend to have more technical complexity and be capital intensive.

The Iconic Island project is located in Sumba islands, a part of Nusa Tenggara Timur Province in the Eastern Indonesia. Hivos, a Netherlands-based international organization seeking solutions to persistent global issues, initiated this project in 2009. Hivos' renewable energy programme focuses on people without modern energy access, and aims to demonstrate that renewable energy is the best choice. They want to provide energy to the island's inhabitants, while at the same time attract interest, cooperation and fundings from institutions and companies inside and outside Indonesia. According to Hivos, this model to bring together all stakeholders can be replicated in comparable remote islands all over the world (Hivos a, 2012).

This initiative was then endorsed by the Ministry of Energy and Mineral Resources as the pilot island of renewable energy. Two agendas are merged in this initiative: renewable energy as a solution to address climate change and as a means to poverty reduction. It aims to demonstrate that all energy demand of a small sized island can be met by renewable sources. The initial goal of "Sumba Iconic Islands" is to electrify the island with 100% of renewable energy supply in 2025 and achieving 95% electrification ratio. The target evolved as it was discovered that there will be a trade-off between

[1] PLN. (2016). Rencana Umum Penyediaan Tenaga Listrik 2016 – 2025 [Electricity Supply Business Plan 2016 – 2025].

the electrification ratio target and the renewable supply target. Three scenarios for energy provision were formulated, and the Stakeholder's Meeting agreed to accelerate the project to achieve 95% electrification ratio by 2020 (Hivos Stakeholder Engagement Officer, personal communication, Jun 8, 2016). The scenario of 95% electrification in 2020 forecasts that portion of grid energy provided by renewables is 65% in 2020 and 68% in 2025.

In selecting the project, Hivos considered how in climate change discourse, small islands are most often mentioned only in the context of their vulnerability to rising sea levels (Hivos a, 2012). The fact that many of small islands are entirely dependent on outside sources of energy tends to be overlooked (Hivos a, 2012). That dependency hinders the inhabitants' development and welfare. Renewable energy can offer the solution for this problem for the island having the potential of local and sustainable own energy sources.

Sumba was selected as the Initiative's location because its inhabitants have low access to energy (24.5% electrification rate in 2010), high dependency on diesel generator (85% of generated power), high transportation costs of oil fuel that has to be taken from other islands (MEMR a, 2015) . Despite the availability of various renewable energy sources, 20% of the population lives under the poverty line (Sumba Iconic Island Secretariat, 2014) and average income is only one fourth of national average (De Groot, 2016). Instead of choosing one particular energy resource to produce electricity, the initiative attempts to utilize all options available on the island, consisting of solar, micro hydro, wind and biomass.

All things considered, island renewable energy transition project carried out in Sumba Iconic Island has the possibility of becoming an important pillar of the future Indonesian energy system. To understand and assess the implementation of Sumba Iconic Island Initiative, this research will make use of system innovation theories. Study on system innovation has shown that "a conscious and intelligent management of innovation processes strongly increases the success chances of innovation" (Luo et al., 2012, p.5). To a large extent it is determined by how the innovation system is build up and how it functions (Hekkert et al., 2011). Many innovation systems are plagued with systemic problems that hinder the development. It is crucial to evaluate how innovation systems are functioning, get the insight of the system's weaknesses and formulate the corresponding policies accordingly (Luo et al., 2012).

1. 2. Problem Definition

Being the first renewable energy transition island project in Indonesia, Sumba Iconic Island sets an ambitious target. Achieving this target is a challenge in itself, considering the characteristic of the island's population, with limited access to energy, limited existing energy infrastructure, high poverty rate, limited purchasing power, low education rate and limited understanding of local actors about renewable energy. Any kind of innovation or modernization introduced in this island will be complicated by the fact that Sumba has a unique culture and social life (JRI, 2013, quoted in Lambooy, T and van't Foort, Sander. 2013, p. 15). Additionally, the concept of open multi-stakeholder engagement underlying the project is also not a familiar approach in Indonesia.

Since the inauguration of the project, Sumba Iconic Island had increased the island's electrification rate from 24% in 2010 to 42% in 2016. There was also an achievement in obtaining broad support and communicating the relevance of this initiative to a wider audience. Among others it resulted in the influence to create similar initiatives, such as Bright Indonesia Program (the national rural electrification program) and the establishment of Indonesia's Center of Excellence for Clean Energy[2]. In spite of the project's outcomes, there remains a substantial gap between renewable energy potential and current implementation.

An ADB study of Least Cost Electrification Plan had recognized that the availability of capital might be a primary challenge of this initiative; therefore the target (100% contribution of renewable energy resources in 2025) might be relaxed to accommodate the available investment. Nevertheless, the alignment of the 95% electrification ratio target with the Government overall target for the country suggests that the project are justified and worthy of the required public and private investment (Castlerock, 2014). With this in mind, acceleration of the initial target to 2020 calls for a more committed collaboration between government, civil society, and private sector.

1. 3. Research Objectives and Research Questions

This study aims to investigate the problems occurring in the implementation of Sumba Iconic Island. In order to achieve this objective, this research will focus on central research question: **What are the systemic problems of Sumba Iconic Island initiative with regard to enterpreneurial activities, knowledge development and diffusion, and mobilization of resources?**

This main research question is elaborated in the following sub-research questions:

1. What are the structural elements of Sumba Iconic Island Initiative?
2. How well does each structural elements function in the implementation of the project?

1. 4. Methodology

The methodology of this research is case study. The case study examines a contemporary phenomenon in its real-life context (Yin, 1984). The reason to choose this method is because the research addresses descriptive and explanatory questions. The contextual conditions are appropriate to understand and analyze the research object. The center of analysis is implementation process, with Sumba Iconic Island as its unit of analysis. It has specific geographical, demographical, social, and cultural characteristics; therefore it is quite difficult to meet similar case for comparison. Given these points, this research applied single case study.

1.4.1. Data collection

For the empirical case study, this research was conducted with the means of primary data. Interview with key stakeholders was the core of data collection. It was started with an interview with Hivos as project initiator as well as coordinator of stakeholder engagement activities. Interviews with other key stakeholders were also done in order to understand their perceptions of how the initiative has been implemented, and to learn about their own activities and resources. The complete list of interviewees is shown in Appendix 1. The design of the interview is semi-structured interview, where the researcher develops an interview guide covering particular topics (see Appendix 2).

[2] Skype interview with Hivos, 1 August 2016. This statement is also mentioned in ADB. (2016). Completion report: Indonesia: Scaling Up Renewable Energy Access in Eastern Indonesia.

To enable a precise understanding of this research paper, it is worth to mention the following methodological issues that may influence the consistencies in which the questions were asked:

1. The questions are tailored according to the need and context in which each stakeholder is involved. This is also considering their input about different domain and level of involvement that was communicated before doing the interview. For example, most questions about function 'knowledge development and diffusion' related to beneficiaries' awareness and knowledge about renewable energy were not asked to central government office, since they are not directly involved in village-level activities. Likewise, the questions about function 'entrepreneurial activities' were not asked to community partner since their activity is limited to their own area.
2. Four interviews were carried out through Skype and three interviews were carried out by email with regard to each interviewee's time availability and convenience. For example, some of them were not familiar with Skype interview or felt more comfortable answering questions via email interview.

To complement the analysis, this research uses secondary data namely published documentation sourced from Hivos and Sumba Iconic Island Website, as well as journal and news article. Additionally, this research reviewed the reports from nongovernmental organisations and international donors to gain insight on project implementation and multi stakeholder engagement process. Studies done by external consultants are also examined. Next to data obtained from published documentation, communication with Hivos and Ministry of Energy and Mineral Resources provided unpublished documentation, such as data presented in Stakeholders' Meetings and deliverables of cooperation with ADB. PT. Nagata Bisma Shakti also supplied unpublished documentation about project update of wind power pilot plan, including its financial calculation and proposal of a joint development with grant provider.

The shortcoming of using secondary data is it may not fully illustrate all elements on the ground. It is also not easy to find documentation regarding process and real interaction involved in this initiative. Together with the selection of relevant data from only highly credible sources, this shortcoming is addressed with the use of interviews to generate rich data. The use of data source triangulation from various sources and different key stakeholders' interviews is expected to increase the validity of this research.

1.4.2. Data analysis

This research is carried out through analyzing interview results and documentation. Firstly, this research will explore structural components of the innovation system namely actors, interaction, institution, and infrastructure. Secondly, a comprehensive discussion on the fulfillment of system functions[3] will be presented. Thirdly, the collected data will be analyzed according to the selected theoretical framework. The conclusions and recommendations will be derived from the analysis.

The assessment of fulfillment of systemic functions to a large extent is done by interviewing key stakeholders. A set of diagnostic questions was asked to key stakeholders about the state of system

[3] System functions is defined as "Specific prerequisites for an innovation system that have to be fulfilled in order for technologies to be developed and implemented successfully within a certain geographic area" (Kroesen and Kamp, 2010, p.3).

structure (actors, interaction, institution, and infrastructure), whether they are sufficient and whether they form a barrier for the system to perform and develop further. The question list is grouped into three system functions where the interviewees are expected to express their views about how each systemic function is fulfilled. Afterwards, the interview responses for each question will be observed to determine whether they match or differ, and to decide whether or not there is an overall similarity. How stakeholders judge the fulfillment of the system is then connected to the literature, as additional source of information about how the system functions and what challenges it faces. A five tier scale (absent – weak – moderate – strong – excellent) is applied to demonstrate the strength or weakness of each function (Luo et al., 2012).

The system functions are evaluated by exploring the following elements:

1. Entrepreneurial activities: the extent of private sector involvement, the expressed interest to do investment, the availability and sufficiency of incentives or facilities from the government for doing investment, the availability of guideline for entrepreneurs, the ease of obtaining business permit or license, and the efforts to increase level of investment.
2. Knowledge development and diffusion: the availability and sufficiency of research activities, the availability and sufficiency of capacity building activities, the means of information dissemination inside and outside project area, the interest of beneficiaries to learn about renewable energy, and the availability of research collaboration.
3. Mobilisation of resources: the availability and sufficiency of natural resources, financial resources, human resources, and physical infrastructure; and the existence of physical challenges of project implementation.

The next step is identifying the structural cause for functional problems. It is analyzed by observing each structural element in two ways: whether the problem arises because of its presence or absence or because of its properties. In addition to four structural elements, it may also be important to look at the external factors or context. Then, the analysis will describe the relation between cause and barrier. It will answer question such as: "What are the functional consequences of the causes in the structure? Do the barriers have to do with a lack of structural components or with lack of quality? What are the effects of the structural components on the functioning of the system – which system functions improve or become worse due to structural problems?" (Hekkert et al., 2011, p. 13).

The systemic problems can be conceptualised in relation to the presence or capacity of the actors, the presence or quality of the institutional set up, the presence or quality of the interaction, and/or the presence or quality of the infrastructure.

The limitation of this research is the number of system functions being studied. A part of the analysis is functional approach proposed by Hekkert et al. (2007), but largely due to the time limitations that this research has to adhere to; only three functions will be examined. It is also important to mention that being context-specific and culture-specific research, the result most likely is not generalisable to other projects or settings.

The next chapter will discuss the rationale of Sumba Iconic Island as the first renewable energy transition project in Indonesia, and the status of its current implementation. It will also present the theoretical framework that is used to diagnose system innovation problems.

CHAPTER 2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2. 1. Background and Introduction

Islands are characterized by insularity, limited range of resources, small markets, specialisation of economies, fragility of ecosystems and skill and labour constraints. These create dependence on fossil fuel, economies of scale loss and higher distribution costs (Vial and Monkhouse, 2010). The need to research and adopt renewable energy technologies are intensified in island economies. Transitioning from fossil fuel will not only create environmental benefits, but also economic and other benefits.

The first part of this chapter introduces the discussion about renewable energy transition in island setting. The second part describes the status of Sumba Iconic Island Initiative. The third part elaborates theoretical framework that construct the perspective of this research, particularly presents theories on identifying systemic problem in system innovation.

2. 2. Island Projects for Renewable Energy Transition

Verbong (2014) defined energy transition as "long-term processes of radical and structural change at the level of energy system". He further proposed how a sustainability transition is more about changing the rules that govern it than about technology, as such radical changes frequently triggers public resistance. However, citizens do not always pose as a barrier, they are increasingly aware of and well involved in energy transition. Verbong argued that the successful transition involves the system that are not only clean, affordable and reliable but also has to be fair and acceptable.

The benefits of energy-self sufficient island have been driving greater investment such as Cradle to Cradle island projects in European North Sea region. There has been a proliferation in the phenomenon of "100% renewable energy island" or the use of island to demonstrate sustainable energy solutions in practice. Another objective of the project is using islands as laboratories and testing areas for sustainable innovations. Due to the smaller population and the limits to resources, islands are interesting and can become suitable case study for testing new energy system, including showcasing the possibility of energy transition to renewable energy. An island is a community of its own, complete in all its components, yet the small scale makes it easier to make an overview. It is expected that the solution that works in island situation can be transferred into macro environment or mainland economies (Energy Transition Centre, 2016).

Several small island developing states throughout the world such as Samoa, Barbados, Nauru, Mauritius and Maldives have been working to achieve climate neutrality through the use of renewable energy to meet the majority, if not the entire, domestic energy needs. By doing this, islands can showcase how to successfully manage and operate power systems with high contribution of variable renewable energy; and at the same time reducing electricity costs, improving the access to modern energy services, stimulating employment and boosting energy security (Amin, 2015). The development of the local and renewable resources provides a solution to decrease the fuel import dependency and reduce risks related to oil price volatility. Furthermore, off-grid energy systems can dramatically improve island's energy access. Beyond energy security and energy access, renewable energy investment is now more cost-effective than ever, and thus for the island context it is cheaper than diesel-generated electricity system (Amin, 2015).

2. 3. Sumba Iconic Island Initiative

Given the abundance of various sources of energy, Indonesia holds significant potential for electricity generation yet experiences challenges in realizing that potential. Ongoing shortages in electricity supply keep on occuring frequently, and on the other hand growth in power demand is expected (Tharakan, 2015). Providing access to electricity for Indonesian populations is not an easy task, considering its characteristic as the largest archipelago country with more than 13,000 islands stretched in about 5,000 kilometers. Despite that challenge, Indonesia achieved remarkable success in accomplishing 88% electrification ratio in 2016. The government c.q. Ministry of Energy and Mineral Resources (MEMR) sets the target to achieve near-universal electricity access by 2020, as stated in 2014 National Energy Policy.

At this point in time, the lowest electrification rate occurs in the outer ring of islands (IEA b, 2015). MEMR pointed out that there are currently 12.659 villages around Indonesia do not have access to on-grid electricity and are largely dependent on diesel-fired generators with very high operational cost. Among this numbers, 2.519 villages do not have electricity access at all, meaning that even the inhabitants cannot manage to have jointly owned diesel generators. The majority of these islands are located in eastern part of Indonesia. There are 56 municipalities with electrification ratio below 50%, on which the majority (46 municipalities) are located in Eastern Indonesia (MEMR b, 2016). Electricity provision and distribution to less developed areas therefore does not only provide economic and social benefits, but also have equity concern.

Remote or rural regions lacking electricity access often experience similar challenges in the form of a considerable distance from national or regional grids, difficult terrain, and harsh climatic condition. They are also often have low population density, low level of education, low load density generally concentrated at evening peak hours and low revenues. The low density makes cost recovery and economies of scale difficult to achieve for off-grid infrastructure investment. Furthermore, without access to electricity, rural poor spend relatively large amount of money for energy, or excessive amount of time for collecting firewood (Bangdadee, 2014). In light of these particular challenges, electricity provision to rural poor needs a committed and long-term action.

Sumba is located in the eastern part of the Indonesian Archipelago. It lies between Sumbawa Island to the Northwest, West Timor to the East and Australia to the far south at a distance of about 700 km. The island is one of the four largest islands in Nusa Tenggara Timur province. Its total land area is approximately 11,052 km^2. The population is 652,259 inhabitants with a density of 58.62 inhabitants per km^2 (Hivos a, 2012). The agricultural sector dominates the economy; despite the land conditions only provide limited support for agricultural activities.

In 2009, Hivos started considering the possibility of renewable energy provision to an island with the aim of completely ending its fossil fuel reliance. The longer term objective of this "Iconic Island"[4] concept is to demonstrate a replicable model addressing both climate change and poverty issues.

[4] 'Iconic' refers to how this project is a showcase to demonstrate the possibility of supplying 100% electricity from renewable energy sources, and also as the first of such project in Indonesia.

In-depth assessment was done to examine the availability and verifiability renewable energy sources in Sumba and Buru, another island candidate. Sumba scored better and it is estimated that renewable energy source is sufficient to meet the electricity need of the island (Winrock, 2010). In a different study, KEMA (a Dutch electricity consultant) concluded that that abundance of wind energy potential combined with hydropower can replace diesel-generated power at lower cost[5]. For off-grid electrification, the best option is utilizing solar panel, while isolated grids can be powered by various renewable energy sources (Hivos b, 2012). Table 2-1 shows the identified renewable energy potential at the planning stage of the program.

Table 2-1 Identified renewable energy potential in Sumba Island

No	Renewable sources	Identified Potential	Summary remarks
1	Hydro	3,335 KW	Excellent hydro potential, both small scale and large scale. Some areas (East Sumba, North coast) are very arid and lack hydro resources.
2	Wind	5 - 8 m/s	Many excellent sites with high average wind speeds suitable for on and off.
3	Solar PV	5.543 KWh/m²/day	Solar radiation is excellent on Sumba and cost effective for off grid sites. Grid connected Solar PV systems are worth considering too.
4	Small biogas	0.86 cattle/capita	Animal husbandry (extensive & intensive) is closely intertwined with daily life for a large part of the population. Biogas development is very suitable.
5	Geothermal	0 MW	No Geothermal potential identified.
6	Biofuel CJO	25,920,000 ltr/yr	Only one 10 hectar site managed by the Plantation Agency identified; shows that there is a technical potential for Jatropha cultivation for biofuels.
7	Bioethanol	123,100 HA	Technically sugar cane could be grown. Lontar palm plantations can be expanded. Value of coconut oil is too high to be attractive for biofuel.

Reference: Winrock International. (2010). Fuel Independent Renewable Energy "Iconic Island" Preliminary Resource Assessment Sumba & Buru Islands – Indonesia.

When Sumba Iconic Island was started none of these sources was yet utilized to their full potential. During the execution of this project, scoping and in-depth studies were carried out, partnerships were formed, and more stakeholders were involved. In engagement phase, official of Ministry of Energy and Mineral Resources immediately supported this initiative due to the alignment with their objectives. This initiative was informally launched in November 2010 at the event of 15th annual Netherlands-Indonesia Joint Energy Working Group meeting in Amsterdam (Hivos c, 2015). In November 2012, Asian Development Bank (ADB) joined to accelerate this initiative, followed by the

[5] KEMA concluded in the 2011 study that renewable options are by far the cheaper options for an island like Sumba at price level of fossil fuel (crude oil prices of about 100 USD/bbl) at that time. The comparison has also been made for the low fuel prices (50 USD/bbl) and high oil prices (150 USD/bbl). It shows that even at low fuel prices hydro generation is very favorable. Wind is also always cheaper compared to the diesel generation also wind is always cheaper. The compatibility of solar depends on the price for diesel oil (KEMA, 2011).

participation of the Embassy of Norwegia to Indonesia in 2013. IBEKA, an Indonesian NGO, also supported SII by providing finance and technical assistance for microhydro power plants. In 2013 MEMR signed the agreement with Hivos and therefore took the responsibility to achieve the renewable energy target. MEMR formally endorsed the Initiative by issuing the Decree of Minister of Energy and Mineral Resources of Republic Indonesia number 3051 K/30/MEM/2015 on the Establishment of Sumba Island as Renewable Energy Iconic Island. In collaboration with stakeholders from government, private sector, local civil society, multilateral NGOs and international donors, the Blueprint and Roadmap for the Initiative 2012 – 2025 was formulated.

Sumba Iconic Island accomplished increasing number of electrification ratio from 24% in 2010 to 42%. Share of grid energy provided by renewable sources accounted for 12,7%. The total capacity of renewable energy installation is 5,693.7 KW and the total investment made for this project amounts to IDR 135,05 billion (as shown in Table 2-2).

Table 2-2 Project achievement

No	Technology	2011	2012	2013	2014	2015	Total
1	Microhydro (PLTMH)	2 unit (52 KW)	5 unit (1.505KW)	3 unit (1.632 KW)	2 unit (232 KW)	1 unit (23 KW)	13 unit (3.444 KW)
2	Centralized/Communal Solar PV *(PLTS Terpusat)*	11 unit (43 KWp)	14 unit (607 KWp)	8 unit (45 KWp)	6 unit (216,9 KWp)	N/A	39 unit (911,9 KWp)
3	Solar Home System *(PLTS Tersebar)*	90 unit (3,1 KWp)	11.054 unit (328,86 KWp)	3.221 unit (87,79 KWp)	464 unit (19,35 KWp)	N/A	14.829 unit (439,1 KWp)
4	Solar Water Pumping	N/A	2 unit (5,16 KWp)	1 unit (1,44 KWp)	N/A	1 unit(1,5 KWp)	4 unit (8,1 KWp)
5	Wind Turbine (non-commercial, household scale)	N/A	N/A	95 unit (47,5 kW)	5 unit (2,5 kW)	N/A	100 unit (50 KW)
6	Biomass (PLTBiomassa)	N/A	N/A	1 unit (30 KW)	N/A	1 unit (1.000 KW)	2 unit (1.030 KW)
7	Biogas	61 unit (360 m3)	221 unit (1.606 m3)	526 unit (4.088 m3)	220 unit (1.412 m3)	N/A	1.173 unit (7.946 m3)
8	Clean Cook Stove	N/A	1.600 unit	375 unit	125 unit	N/A	2.100 unit
9	Smart Street Lamp	N/A	N/A	N/A	N/A	480 unit	480 unit
10	Barsha Pump	N/A	N/A	N/A	N/A	2 unit	2 unit

Reference: De Groot, R. (2016). Climate Finance: Sumba Iconic Island 100% Renewable Energy by 2025. [Presentation files]

Table 2-3 Comparison between renewable energy potential and its current implementation

No	Type of renewable energy/technology	Potential	Installed
1	Run off River (RoR) Hydropower	7.1 MW	3.421 KW (12 unit Microhydro)
2	Storage Pump Hydropower	8.5 MW	0 unit
3	Solar Power	10 MW	- 9,119 KWp (39 unit) community mini-grid - 439 KWp panel (14,829 unit) - 6,6 KW (3 unit) solar powered water pump
4	Windpower	10 MW	50 KW (100 unit)
5	Biomass	10 MW	30 KW (1 unit)
6	Biogas	8,962,870 m3	7946 m3 (1173 unit)

Reference: De Groot, R. (2016). Climate Finance: Sumba Iconic Island 100% Renewable Energy by 2025. [Presentation files]

As important as the achievement is, the table above demonstrates that there remains a substantial gap between renewable energy potential and current power plant implementation, and the island is still struggling in adapting renewable energy technology. Several problems remain in the field such as broken down installations due to lack of maintenance. In addition, PLN (the state-owned utility) estimates the cost of installing power lines to electrify all population is $22,000 per 0.6 miles. This number is too high for PLN to consider installing a central power utility. However, the decentralized nature of small-scale renewable projects may complicate this problem, with lines only being installed in localized areas (Creed and Warner, 2016). Another problem is dealing with long and complicated process of obtaining business licenses. A project developer must have several different kinds of permits or licenses, among others are principle, location, business area, and power plant operating license. Such licenses are needed to be to be obtained from several different authorities (MEMR c, 2016).

2. 4. Theoretical Framework to Analyze System Innovation Problems

The concept of "innovation system" was first used in published form by Freeman in 1987 (Edquist, 2011). The emergence of this concept upgraded the previous view that look at this process as a continuous progression of scientific research. Innovation system is defined as "The network of institutions in the public and private sector whose activities and interconnections initiate, import and diffuse new technologies" (Freeman, 1987 as cited by van Alphen et al., 2008). This definition reflects a complex combination of institutions, public policies, and social relationships that are involved in technology transfer (van Alphen et al., 2008). Innovation scholars argue that organizations innovate in the context of the system, thus their performance depends on the quality of systems and particularly that of related subsystems -- research & development, users, intermediary and supportive infrastructure. Furthermore, the process involves implementation of new ideas to bring about the desired social and economic outcomes (Hall, 2005).

The earlier development of innovation system focus on business context where firm plays a central role and placed at the center of the analysis. Innovation in the broader, non-business context increasingly emerged afterwards, consisting of user innovation, public sector innovation, social innovation, and innovation for inclusive development. The emerging types of innovation can be distinguished from business innovation in the following ways: (1) aim of innovation; (2) driving force of innovation; (3) actors in innovation; (4) contextual conditions and institutional setting of innovation; (5) understanding of knowledge flow; and (6) the policy needs for effective design and implementation (Iizuka, 2013).

Social innovation is participatory in nature, aimed at constructing behavioral shift toward environmental sustainability or public goods, such as community energy project. Social innovation is especially useful in the effort to address global, crossborder challenges by combining the strength of multiple stakeholders – government, agencies, business, and NGO (ISABEL Consortium, 2016). The discussion of social innovation started in the work of Drucker and Young in 1960. Until five decades later there is still lack of theoretical evidence on the definition, as well as standard approach to address the problems. Due to the intricate and wide-ranging nature of the problems, social innovations tend to be designed on case by case basis, through borrowing and mixing various existing approaches (ISABEL Consortium, 2016).

OECD offers working definition for social innovation as:

> “dealing with the welfare of individuals and communities, both as consumers and producers. The elements of this welfare are linked with their quality of life and activity. The key distinction (from economic innovation) is that social innovation deals with improving the welfare of individuals and communities through employment, consumption and/or participation, its expressed purpose being to provide solutions for individual and community problems." OECD (2000, p.21)

This definition clearly link social innovation with local development. Similarly, Harris and Albury (2009) defined social innovation as:

> “innovation that is explicitly for the social and public good; innovation inspired by the desire to meet social needs which can be neglected by traditional forms of private market provision or be poorly served or unresolved by services organized by the state. Social innovation can take place inside or outside of public services and can be developed by the public, private or third sector, users and communities”. Harris and Albury (2009, p.5)

Based on those definitions, Sumba Iconic Island can be categorized into social innovation, as it is designed to provide electricity access to underserved community, with the objective to boost local economic activity that eventually will improve their wellbeing.

In order to investigate the problems occurring in the implementation of Sumba Iconic Island, this research will use ***the combination of structural analysis and functional analysis*** of technological innovation system developed by Wieczorek and Hekkert (2012). The interest of this research is creating insights into the development and diffusion of renewable energy in island settlement. In this context, technological innovation system is most suitable approach since it focuses on a particular technology and includes factors that are specific to the technology studied. Several parts of the analysis will also be adapted from systemic policy framework developed by Utrecht University scientists (M. Hekkert, S. Negro, G. Heimeriks, R. Harmsen) in 2011.

Comparing the structure of different innovation systems has been long used to analyze the reasons of success or failure of a specific innovation system. Nevertheless, specific characteristics of the elements are challenging to be directly transferred from a system to another. The functional approach emerged to emphasize the important process to ensure good performance of innovation systems. Both have similar foundations but were separately developed and used. Combining both approaches into a consistent policy framework can provide a much more complete picture of the system. Structural analysis provides insight about who is active in the system, while functional analysis provides insight in what they are doing and whether this is sufficient to develop successful innovation (Hekkert et al., 2011).

To begin with, this research will analyze the structure of Sumba Iconic Island. It will be followed by the analysis on how well they function, and the actual interaction between functions. Then it will proceed to identify problems that hinder the development. There are four types of systemic problems: actors, institutional, infrastructural, and interaction problems. The problems identified based on the examination of the factors that obstruct specific functions. These factors are then linked to the structural elements of the system. To put it another way, the system functions that are not well fulfilled are a manifestation of problems in the structure.

The coupled functional – structural analysis captures the dynamics in the system, and therefore offers a good overview of what happens in the system. This is particularly useful with regard to what goes wrong and why. The coupled functional – structural will make it possible to specify which of them need to be altered, and how, to increase the entire system performance. This provides a systematic input to policy decision making and the design of an integrated systemic policy instrument to address the problems in a more orchestrated manner (Wiezcorek and Hekkert, 2012).

Structural analysis

All innovation systems have the same basic building blocks or structure as follows:

1. Actors
   Smits and Kuhlmann (2004) argued that the distinction between producers and users is now increasingly blurred, since users are also involved in innovation processes during the design stage and the actual use of innovations. Thus it will be more useful to differentiate actors in terms of their role in economic activity. Wiezcorek and Hekkert (2012) delineated actor categories based on their role: civil society, government, NGOs, companies (start-ups, small and medium-sized enterprises, multinationals, large firms), knowledge institutes (universities, technology institutes, research centres, schools), and other parties (legal organisations, financial organisations/banks, intermediaries, knowledge brokers, consultants). These different actors can serve different roles.
2. Institution
   Institutions involves a set of common habits, routines and concepts used by humans in repetitive situations (known as soft institutions) organised by rules, norms and strategies (known as hard institutions) (Crawford and Ostrom, 1995 as quoted in Wiezcorek and Hekkert, 2012).
3. Interaction
   Interaction is a dynamic element, and thus some scholar prefer to use the term "network" but Wiezcorek and Hekkert (2012) argued that interaction is not restricted within network. Interaction focuses on relationships and how they can be analysed at the level of networks and individual contacts.
4. Infrastructure
   Infrastructure is where actors, institution, and interaction operate. Three categories of infrastructure are proposed as structural elements of the innovation system as follows:
   - Physical infrastructure includes artefacts, instruments, machines, roads, buildings, telecommunication networks, bridges and harbours.
   - The knowledge infrastructure includes knowledge, expertise, know-how and strategic information.
   - The financial infrastructure includes: subsidies, financial programs, grants.

Functional analysis

Though different innovation systems are made up from similar structure, the structure may perform in a completely different manner. The functional approach analyzes specific prerequisites that have to be fulfilled so that technologies is developed and implemented successfully in a certain geographic area; these prerequisites are called functions (Kroesen and Kamp, 2010). There are various innovation system approaches with different identified functions (Hekkert, 2007; Bergek, 2008; van Alphen, 2008). Each list of system functions has slightly different emphasis, depending on the context in which the list was developed. Hekkert emphasizes the main role of entrepreneurial activities, whereas Bergek puts more emphasis on knowledge development and diffusion (Kroesen and Kamp, 2010). Despite the slight difference, those lists of functions show shared understanding of basic functions that has to be served by an innovation system.

The concept of function contributes to innovations system by:

- Providing a tool for setting system border so that it will not include all components that influence the functions.
- Providing a tool to describe the present state of a system.
- Function may be useful to study innovation system dynamics and understand how innovation systems emerge and change.
- Allowing the assessment the performance of an innovation system, i.e. how well a particular function have been served (Johnson, 1998[6]).

There are multiple interactions between functions and they influence one another. The fulfillment of these functions can positively or negatively affect the whole performance the system; therefore it can lead to virtuous cycle of change processes within the innovation system (Jacobsson and Johnson, 2000, cited in Hekkert et al., 2007). Nonetheless, Wiezcorek and Hekkert (2012) argued that functions alone are not a sufficient to develop successful systemic innovation policies because of two reasons. Firstly, functions cannot be influenced without changing the correspondent structural element. Secondly, making function the only basis will result in uncertainty about completeness of identified blocking mechanisms and policy issues. The analysis of this research will follow this argument.

Hekkert et al. (2007) proposed seven functions of innovations that stem from theory and are empirically validated as indicators[7]. These functions are based on Innovation System dynamics in developed countries and need to be adjusted to the situation where developing countries are confronted with technology transfers, as pointed out by van Alphen et al. (2008) and Lundvall (2004). For example, a country may not be capable of developing appropriate technology domestically, while innovation scholars emphasize that the creation of new scientific knowledge by research and development is one of the key functions. Kroesen and Kamp (2010) also mentioned that successful implementation requires match between the western-based technology and the

[6] Johnson was Anna Bergek's maiden name

[7] The complete list of functions of innovation proposed by Hekkert et al (2007) are Entrepreneurial activities, Knowledge development, Knowledge diffusion through networks, Guidance of the search, Market formation, Resource mobilization, Creation of legitimacy/counteract resistance to change.

local context of developing countries. What involved in this process are not only knowledge and skills, but also attitudes, social interaction and values (Kroesen and Kamp, 2010).

Considering the suitability of these functions for Sumba Iconic Island Initiative as social innovations, this research will examine three functions that are most relevant to the case study. Firstly, according to phase of development categorization (Hekkert et al., 2011) Sumba Iconic Island is on the development phase - indicated by the presence of commercial application. In this phase 'entrepreneurial activities' is the most important system function because the first commercial experiments will show whether the innovation also work in practice. Secondly, the function 'knowledge development and diffusion' is relevant for Sumba because there is the need to build solid evidence base for intervention through research and development for such a new business venture. At the same time, developing the capacity of local residents to build and maintain their own energy supply is also required, since renewable energy is considered as a new technology in this area. Thirdly, the function 'mobilization of resources' is relevant for Sumba since it needs enormous amount of new investment to achieve the objective, no less than USD 428.4 million by 2020 (Hivos d, 2016); in addition to the requirement to allocate sufficient natural resources and human resources.

The explanation of three system functions is as follows:

1. Entrepreneurial activities

   This function involves projects that show the usefulness of technology in practical and commercial development, usually in the form of experiments and demonstrations. Entrepreneurs are indispensable for a well-functioning innovation system, to turn the potential of new knowledge and market into real projects and create business opportunities. Therefore, the presence of active entrepreneur is considered as the main indicator of how innovation system performs. When entrepreneurial activities slow down, it may be caused by other six functions. When the innovation system is developed well in terms of other six functions, conducive business climate may arise. The essential role of entrepreneurs for a flourishing system is to realize the potential of new knowledge, network, and markets into concrete actions; as well to generate new business opportunities (Hekkert et al., 2007).

2. Knowledge development and diffusion

   Knowledge development and diffusion are among seven functions proposed by Bergek et al. (2008). Although similar with Hekkert's list that was primarily developed for the analysis of technological innovation system in Western countries, Bergek's list put forward the idea that knowledge development is the central function within an innovation system. The use of this function allows for a more well-rounded assessment of the system better than 'knowledge diffusion'.

   The function captures the breadth and depth of the current knowledge base and exchange of knowledge between the relevant actors and interaction between them. According to Carlsson and Stankiewicz (1991) quoted by Hekkert et al., the essential function of network is to exchange information. Information exchange is important particularly in a heterogeneous context where research & development activities interact with government, competitors, and market. Policy decision, such as standard and target, should be consistent with the latest technological findings. At the same time, research & development agenda should be affected by changing norms and values. Network activity is considered as precondition for function knowledge development (learning by interacting and learning by using). In the particular context of developing countries, Lundvall (2004) emphasized that learning processes form the precondition for innovation. Under certain conditions, learning processes "enhances the capability of individuals and collectives to utilize and co-exist with their environment it contributes directly to human wellbeing" (p.28). To transfer tacit knowledge (e.g. human expertise), close and intensive face-to-face contact is required and geographical proximity can accommodate this type of communication (Luo et al., 2012).

This function can be analysed by mapping the number of research and development projects, workshops and conferences devoted to a specific technology topic (Bergek et al., 2008; Hekkert et al., 2007). Lundvall (2004) suggested examining various kinds of learning going on in society related to Doing-Using-Interacting mode of innovation, i.e. in rural areas, villages, firms and organizations. Only a part occurs in formal setting such as education and research system. Lundvall argued that it is important to understand how and to which extent individuals, communities, firms and organization are geared to learning; and whether or not there is a 'learning culture' in place.

3. Mobilisation of resources

   This function involves allocating financial, material, and human capital, and sometimes also natural resources, in order to develop the technology. Resources are needed as a basic input for all activities in the system. The performance of this function can positively or negatively influences other system functions. Hekkert et al. (2007) gave the example of funds for research activities to develop specific technological knowledge (as an input for function 'knowledge development and diffusion'), or funds to test new technology in niche experiments (function 'entrepreneurial activities'). Although it is difficult to assess the fulfillment of this function through specific indicators over time, Hekkert proposed to explore whether or not inner core actors perceive access to sufficient resources as problematic. This kind of exploration is done in this research by asking the stakeholders about how they view the adequacy of public and private funding, as well as looking at the state of renewable energy projects financing in Indonesia.

Systemic problems

Many innovation systems are often characterized by flaws that obstruct the development and diffusion of innovation. This research will refer to flaws, failures and weaknesses as systemic problems. Wiezcorek and Hekkert (2012) defined systemic problems as "factors that negatively influence the direction and speed of innovation processes and hinder the development and functioning of innovation systems". Innovation policy assesses how innovation systems are functioning to create insight in the systemic problems and develop policy correspondingly.

The next step of analysis is identifying the structural cause for functional problem. The systemic problems can be conceptualised in relation to:

- The presence or capacity of the actors
- The presence or quality of the institutional set up
- The presence or quality of the interactions

- The presence or quality of the infrastructure

To express the properties and attributes of the various structural elements terms like capacity, quality or intensity are used in both the positive and a negative sense. For example an interaction can be too intense or too weak, an institution can be too stringent or too weak, relevant actors may be absent or lacking capacity to develop vision and strategies, and specific type of infrastructure is inadequate or malfunctioning (Wiezcorek and Hekkert, 2012). The analysis will be presented in Section 4.5. table 4-3.

Step-by-step application of framework

Step 1: Mapping structural elements and their capabilities to support the implementation of Sumba Iconic Island initiative

Step 2: Creating the link between structural – functional analysis. Which structural element causes the weakness or absence of the function will be identified.

Step 3: Identification of systemic problem. Once it is discovered whether or not the weakness of the function has something to do with actors, institutions, interactions or infrastructure, the next step will be to explore whether the problem occurs because any of these are missing or there is a problem with their capacity. This analysis is carried out for all three functions in order to identify where exactly the problem is.

2. 5. Conclusion

Sumba Iconic Island, as the first renewable energy transition island in Indonesia, has increased the electrification ratio during its implementation for several years. However, there is a substantial gap between renewable energy potential and current power plant implementation. Additionally, several problems in the field show that the island right now is still struggling in adapting renewable energy technology.

This chapter has presented the theoretical framework that is useful to diagnose the project implementation of Sumba Iconic Island, namely structural-functional analysis. It will be applied by first identifying absent or weak system function that can pose barriers for the progress of technological diffusion and development. Then it will establish the link between functional problem and its structural cause; in relation with the presence, capability, or quality of each system function.

CHAPTER 3. STRUCTURAL ANALYSIS OF SUMBA ICONIC ISLAND

This chapter will elaborate the building blocks that make up Sumba Iconic Island initiative. Structural analysis of this system is based on mapping its elements and evaluating the elements' capacity to support the implementation of renewable energy projects. Wieczorek and Hekkert (2012) argued that the structural elements presence/absence and capacities are critical to the functioning of the innovation system, and therefore can help in further understanding systemic problems.

3. 1. Actors

Sumba Iconic Island is a multi stakeholder initiative that relies on active participation and engagement. It brings different actors together to discuss and implement renewable energy project. This part will explain the key stakeholders involved, the role they play, and in what capacity. It will include actors from the outset of the initiative and actors that withdrew their involvement at a later stage of its development.

Hivos chose Indonesia as the site of this initiative due to its existing presence in the country. This selection enables the initiative to benefit from Hivos' profile, networks, knowledge and staff, and experience with micro hydro and biogas (Hivos, 2015). Hivos set up this initiative in 2009 and started approaching main stakeholders to be actively involved. The stakeholders are government from various level of governance (central, provincial and district), state-owned electricity company, local civil society organization, national and international NGO partners, donor organization, private sector and last but not least the project beneficiaries. The central actor from the government side is Ministry of Energy and Mineral Resources (MEMR). MEMR took the responsibility of achieving Sumba renewable energy objective in 2013[8]. Further, with consultation with all stakeholders, MEMR issued the Roadmap and Blueprint that set the target of 100% renewable energy island in 2025.

Hivos has an office in Waingapu, Sumba Timur. However, the main offices of Sumba Iconic Island are in fact considered to be in four district government offices (Sumba Barat, Sumba Barat Daya, Sumba Tengah, and Sumba Timur). The focal point is the Chairman of each district's Mining and Energy Agency and Local Development Planning Agency, supported by various agencies.

The state-owned electricity company, PT. Perusahaan Listrik Negara (Persero) is a key actor in this initiative, since this agency is responsible for providing electricity to all citizens particularly those lacking electricity access. Sumba Iconic Island is included in PLN's *Rencana Umum Penyediaan Tenaga Listrik* (Electricity Supply Business Plan) since 2016. There is indeed a strong alignment between Sumba Iconic Island initiative and PLN's own goal and target that helped fostering the engagement. National energy policy instructs PLN to reduce its fossil fuel dependency and increase the share of renewable energy. Additionally, the achievements of this initiative align well with PLN interests, such as fuel saving.

[8] MOU between MEMR and Hivos 'on Cooperation relating to Sumba as Iconic Island for 100% renewable energy' signed on 13 February 2013. MEMR officially authorized this initiative by issuing Ministerial Decree no 3051 K/30/MEM/2015 that formalized Sumba Island as renewable energy iconic island.

Explanations of the role of each key stakeholders are displayed on the table below.

Table 3-1 Role of stakeholders

No	Stakeholders	Role
1	Hivos	Secretariat and independent advocate of Sumba's renewable energy plans
2	Government agencies	
	Central government	• Ministry of Energy and Mineral Resources Provide funding for renewable energy installation and capacity development, support the execution of Investment Forum. • Related institutions (Ministry of Development of Disadvantaged Regions, Ministry of Marine and Fisheries) Provide funding for renewable energy installation.
	Nusa Tenggara Timur Provincial Mining and Energy Agency	Provide financial support for renewable energy installation.
	Four district government: Sumba Barat, Sumba Barat Daya, Sumba Tengah, Sumba Timur	Oversee the day-to-day operation, directly communicate with the local residents
3	State-owned electricity company, PT. Perusahaan Listrik Negara/PLN (Persero)	Build renewable energy installations, aim to carry out grid interconnection and extension to increase electrification rates, and distribute SEHEN household solar PV systems for lighting.
4	Local civil society organizations: • Yayasan Sosial Donders, Yayasan Alam Lestari, and Yayasan Sumba Sejahtera • Local media: Max FM Radio Fox Mundi Radio	In preparing renewable energy installations, Hivos collaborated with local NGOs to support community mobilizations and negotiations, which is critical to the projects' success. Local media disseminate updated information on renewable energy projects to their listeners.
5	Community partners: Koperasi Jasa Kasih in Kamanggih village	This cooperative performs an active role in the construction of micro hydro power plant by preparing the community and building their sense of belonging of the project.
6	International and national NGO partners: • Winrock • IBEKA	Conduct research, carry out implementation of showcase projects and provide technical assistance. They also brought their own resources and network, as well as inviting other funding sources to be involved in this initiative (Hivos, 2015).
7	Donor organization	• Asian Development Bank: conduct diverse research and feasibility studies through Castlerock Consulting (2012-2016). A markedly important study scrutinizes the

No	Stakeholders	Role
		potential of each renewable energy source. This study was aimed at further encouraging private sector investment. • GIZ: conduct capacity building activities in the form of technical assistance to government institution. • Norwegia Embassy/NORAD: provide fund to support ADB program, to enable Hivos to host the secretariat, and also to implement renewable energy projects. • Millenium Challenge Account: is recently planning to develop small-scale business model with service centers providing solar- and biogas-based energy and services for community groups. • Private sector corporate social responsibility funding, for example from Indonesian bank BNI to develop biogas digester and micro hydro project, and from state oil company Pertamina to develop micro wind project.
8	Private sector	• The involvement is started by PT. Nagata Bhisma Sakti in 2012 with the plan to do wind power feasibility study, and build a pilot wind project with 500 kW generating capacity, before launch the commercial operation. This company pulled out of the investment in 2014. • PT Len Industry signed cooperation agreement with District Government of Sumba Barat in April 2016 to develop solar power plant.
9	Local residents	• Use, operate and maintain renewable energy installation • Propose the installation of renewable project in their settlements

Additionally, there are also support organizations that are not covered by the above categories but that in some capacity do contribute to the development of the system (Luo, 2015). These are financial organization such as banks, and knowledge producer such as research centers and consultancies.

It is in the local government plan to take over the role and function of district mining and energy agency to provincial level. Since now the main offices of Sumba Iconic Island is considered to be in district government offices, which is the nearest governance level to the project beneficiaries, this may affect the achievement of Sumba Iconic Island target.[9]

3. 2. Interaction

Interaction is a dynamic element that focuses on relationships and how they can be analyzed at the level of networks and individual contacts (Wiezcorek and Hekkert, 2012). While the presence and capacities of the actors elaborated in the previous section are very important for the functioning of

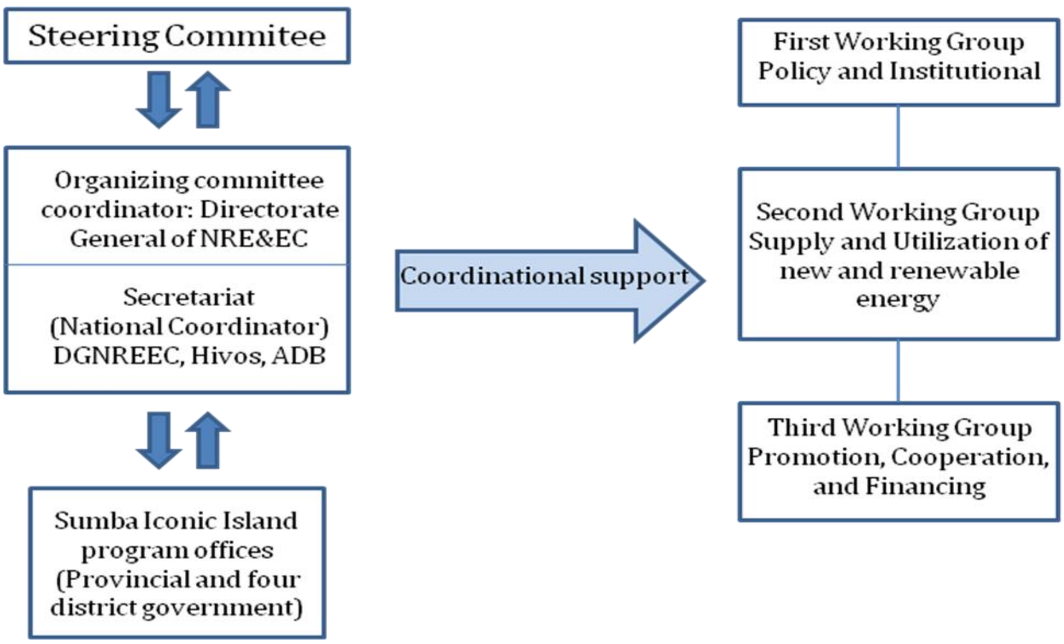
[9] Skype Interview Sumba Barat Daya district government

innovation system, system development also relies on the cooperation between the actors. The cooperation may occur at various levels, from within actors' group, among actors' group or across the whole system (Luo et al., 2012).

In Sumba Iconic Island initiative, the interaction across the whole system is formalized into what is called as 'Working Group'. All decisions of the project are made through Working Group meetings. These meetings serve as a holistic coordination network to update who is doing what and how to achieve one single goal. Members of the Working Group are appointed in a formal document, decree of Director General of New Renewable Energy and Energy Conservation, to enable related parties to allocate budget for this initiative. This decree is updated annually in accordance with newest development of the initiative. Included in the decree are also local stakeholders, such as civil society organizations, cooperatives, lecturer from local state university, and local radio. Coordination activities are organized in every level. Stakeholders in district level conduct meetings to gather recent renewable energy implementation data from each district and discuss actual issues. Results from this meeting will be brought up in national plenary meeting. The biannual plenary meeting coordinates all three working groups. This meeting also serves as a means for all supporting agencies to report current renewable energy development and related studies, seek solutions to issues, as well as promote the program to potential investors and donors. In all stakeholder meetings, SII Secretariat will organize the activities and report the result to Steering Committee (SII Secretariat, 2014).

The governing structure of Working Group is illustrated in below figure.

Figure 3-1 Organizational structure of Working Group



Reference: SII Secretariat. (2014). Blueprint & Roadmap Sumba Iconic Island 2012-2025.

3. 3. Institution

Institutions involves a set of common habits, routines and concepts used by humans in repetitive situations (known as soft institutions) organised by rules, norms and strategies (known as hard institutions) (Crawford and Ostrom, 1995 as quoted in Wiezcorek and Hekkert, 2012). This part will explain both soft and hard institution involved in Sumba Iconic Island.

3.3.1. Initiative's target

As Sumba Iconic Island progressed, it was discovered that there would be a trade-off between renewable energy share target and electrification ratio target. In April 2015, the Working Group agreed to accelerate the initial target; the new target is achieving 95% electrification ratio in 2020[10]. This new target requires addition of new renewable capacity as fast as possible. The breakdown of the scenario with the projected renewable capacity and annual funding required through 2020 is on the below table.

Table 3-2 Scenario to Achieve 95% Electrification Ratio by 2020

Project	Capacity (MW)	2015 (USD mil)	2016 (USD mil)	2017 (USD mil)	2018 (USD mil)	2019 (USD mil)	2020 (USD mil)	Total (USD mil)
Electrification Ratio		29%	32%	42%	59%	80%	95%	
Renewable Share		30%	42%	34%	38%	40%	65%	
Public Generation	14.1	1.5	-	12.0	14.4	-	-	28.0
Microhydro power plant	0.6	1.5	-	-	-	-	-	1.5
Gas machine/diesel power plant	12.5	-	-	9.9	11.1	-	-	21.0
Biomass power plant	1.0	-	-	2.1	3.3	-	-	1.4
Private generation	27.4	3.8	4.9	14.3	34.0	36.8	11.5	105.3
Microhydro power plant	4.4	3.8	2.2	0.9	1.1	0.5	0.4	9.0
Wind power plant	10.0	-	-	-	16.3	25.8	-	42.0
Solar power plant	10.0	-	2.7	13.3	16.6	3.5	-	36.1
Biomass power plant	3.0	-	-	-	-	7.0	11.1	18.1
Dam type hydro power plant	8.5	-	7.5	15.8	20.8	22.0	18.6	84.7
Network and miscellaneous		6.7	11.2	27.0	46.3	44.5	46.8	182.6
Off-grid and mini-grids		0.7	0.7	3.4	5.6	8.0	86.5	27.9
TOTAL (Excluding existing)	50.0	12.6	24.3	72.5	121.2	111.3	86.5	428.4

Reference: Castlerock c. (2015). Inputs to the Sumba Iconic Island Road Map.

The scenario clearly shows that a substantial part of the required funding for electricity generation comes from private sector generation. ADB's project completion report also pointed out that private sector is principally responsible for renewable generation development (ADB,2016). This is part of reasons why the Secretariat has focuses its activity toward foster private sector engagement[11]. On the other hand, the public funding requirement is also huge, especially for building new network. The target requires new installation of 2.600 low voltage lines and 1.140

[10] Hivos Stakeholder Engagement Officer, personal communication, Jun 8, 2016
[11] Skype Interview Hivos

medium voltage lines which are about 10 times of current annual rate; and 93.000 new connection from 2017 to 2020 (MEMR c, 2016).

3.3.2 Financial incentive

Financial incentive for this initiative comes from the government. There is no difference between financial incentive and licensing process prevailing in this initiative to that of in other parts of Indonesia. Incentive comprises of technology specific incentive and generic incentive. Technology specific incentives are given in the form of feed-in-tariff.

The primary policy driving the development of small-scale renewable energy generation by independent power producers was feed-in-tariff introduction by Ministerial Decree no 31/2009. This regulation offers a guaranteed purchasing price for a period of up to 20 years for renewable energy independent power producers of less than 10 MW capacity. Before the introduction of feed-in-tariff, small scale projects were largely designed, engineered and financed by PLN (Cameron and van Tilburg, 2016). Because the incentive is relatively new, it also has impacts of the sector that will be discussed later in Chapter 4.

Feed-in-tariff regulations relevant to the renewable energy projects in Sumba Iconic Island are:

1. Hydropower: Ministerial Decree no 19/2015 on electricity purchase of Hydro Power Plant with capacity up to 10 MW by PT. PLN (Persero) with the tariff of 9,30 – 11 cents USD/kWh.
2. Solar: Ministerial Decree no 17/2013 on electricity purchase of Photovoltaic Power Plant by PT. PLN (Persero) with the tariff of 25 – 30 cents USD/kWh. This regulation has been annulled by Supreme Court. The government is currently formulating a replacement regulation.
3. Biomass and biogas: Ministerial Decree no 27/2014 on electricity purchase of Biomass Power Plant and Biogas Power Plant by PT. PLN (Persero) with the tariff of Rp. 1.050 – Rp. 1.500/kWh. The government is currently formulating a new regulation with the emphasis of revising feed-in-tariff for these renewable energy sources so as to attract more investors.

There has yet to be any regulation on wind power feed-in-tariff despite the frequent references in media that the government will issue this regulation in immediate period. The formulation of this regulation is reaching the final stage, with some issues still being discussed such as pricing and purchasing mechanism[12]. Another related regulation is MEMR Regulation No. 4/2012 stipulating that PLN has the obligation to purchase power from renewable energy projects under 10 MW (Low Carbon Support Programme to Ministry of Finance, Indonesia, 2015). Tariff levels depend on the installation type, location and voltage of grid interconnection.

There are several generic incentives that in paper enable renewable energy companies to obtain tax reduction[13] as follows:

1. The main fiscal incentive for renewable energy is regulated by Ministry of Finance Regulation no 21/PMK.011/2010. This regulation granted tax reduction and custom facility for all renewable energy production, as well as production and import of machines.

[12] MEMR Regulation Bureau, personal communication, 20 May 2016

[13] Low Carbon Support Programme to Ministry of Finance, Indonesia. (2015). Final report: a coherent fiscal policy framework for promoting renewable energies and energy efficiency in indonesia.

2. The similar tax reduction and custom facility regulated by Government Regulation 52/2011 (carried out through 144/PMK.011/2012) with clearer application and approval procedures for specific sectors. The specific sectors are regarded as having high developmental priority in national scale, one of which is renewable energy.
3. Renewable energy companies might be eligible as 'pioneer industry' and therefore can request additional income tax holiday for 5 – 10 years since commercial operation date, based on PMK 130/2011.

However, the fiscal policy related to renewable energy is not functioning adequately. It is not always easy to obtain the incentive in practice since the application process is lengthy and uncertain (Low Carbon Support Programme to Ministry of Finance, Indonesia, 2015). Frequent changes in feed-in-tariff, as much as it is important to enable a better tariff and attract more investment, also create uncertainty for investors.

3.3.3. Expectation and social acceptance of renewable energy

Ever since before the initiative started, the local PLN office was highly supportive of renewable energy utilization and had successfully operated a microhydro power plant for years. Local PLN office also owned significant amount of detailed renewable energy sites information that represents good prospect for future development and cooperation (Winrock, 2010).

The beneficiaries' interest to learn about renewable energy is varied between four districts. Hivos reported that the interest is generally high, reflected from consistent operators' commitment all over the island to maintain the projects and community's willingness to provide land to be used for renewable energy projects[14]. In some areas, the community also expresses their intention to enroll in operation and maintenance training and to propose local renewable energy installation. However, the level of understanding of renewable energy is still relatively low and further awareness building is needed[15].

3. 4. Infrastructure

3.4.1 Physical infrastructure

The presence and sufficient capacity of physical infrastructure is crucial for development and the subsequent functioning of the innovation system (Luo et al., 2012). In selecting Sumba as the site for Iconic Island initiative, physical infrastructure was one of the most important considerations and gave Sumba better score than other island candidate. The preliminary resource assessment shows that the accessibility by plane from Jakarta is easy, with two airports in this island: Tambolaka in Sumba Barat district and Waingapu in Sumba Timur district. Seaport harbor is located in Waingapu and the harbor facilities allow large ships. The roads are relatively well developed and mostly made from tarmac, although the study shows that not all roads are in good condition (Winrock, 2010).

Nowadays the main roads from Sumba Timur district to Sumba Barat district are good and adequate. The infrastructure in Sumba Island is better in particular when compared with other parts of Eastern Indonesia, which is considered to be the least developed region. The port operates quite

[14] Skype interview Hivos
[15] Skype interview Sumba Barat Daya district government

actively. The port facilities are sufficient to transport solar PV and hydropower turbine. Nevertheless, there are limitations related to infrastructure capacity to support new renewable energy technologies that will be detailed further in the coming chapter.

Electricity is principally generated by high speed engines operating on light transport-grade diesel. Sumba's main grids are located at Waingapu, Waikabubak, Lokomboro (run of river hydro), Malata and Waitabula. There are a number of other smaller grids that are either standalone or have the ability to be interconnected to either the main grid sections or each other. The use of lease sets is common to meet rapidly increasing demand at the level of 10% annually (Castlerock a, 2014).Regarding renewable energy potential, in the western and central parts of Sumba, micro hydro, solar PV and biogas is especially relevant; while in the eastern part, small wind and solar PV are more relevant (Winrock, 2010).

3.4.2. Financial infrastructure

Besides physical infrastructure, availability of funds for installation of renewable energy projects largely influences the operation of the innovation systems (Luo et al., 2012). To achieve the Initiative's target, it requires USD 428.4 millions new investment by 2020 as described in table 3.1 above. Private and public funding is needed at the same extent. While private sector and PLN can invest in in off-grid systems and grid-connected generation, network infrastructure investments are solely PLN's domain (Castlerock, 2014).

For off-grid electrification, there is a variety of public financing options. Funds from central government come from MEMR, Ministry of Underdeveloped Regions, and Ministry for Cooperatives (Ritter, 2011). MEMR started providing Dana Alokasi Khusus Listrik Pedesaan (Rural Electrification Special Allocation Fund) in 2011. This scheme requires district government's active role to have completed feasibility study. This poses a risk to the program implementation since the district government usually does not have enough experience in compiling good FS. Furthermore, MEMR expects district goverment to support institutional capacity building for setting-up village utilities and respective trainings by themselves (Ritter, 2011). In reality, the amount of available fund from district and provincial government is very limited. Information obtained from the interview with MEMR office suggests that due to the limited state budget and the vastness of area needing electricity, it will be very hard to achieve the target. Interview with private sector also suggests the limited private sector funding, due to the escalation of capital cost.

3. 5. Conclusion

This chapter has explored four structural components of Sumba Iconic Island and assessed each structure's capacity to support renewable energy projects implementation. This represents the static aspect of the system, because the structures are relatively stable over time. Analysis in this chapter provides insight about who is active in the system. The following chapter will provide insight in what the structure are doing and whether this is sufficient to develop a successful innovation (Hekkert et al., 2011).

CHAPTER 4. FUNCTIONAL ANALYSIS OF SUMBA ICONIC ISLAND AND INDENTIFICATION OF SYSTEMIC PROBLEMS

Taking departure from the structural elements explained previously, this chapter will answer the sub-question: **How well does each structural element functions in the implementation of Sumba Iconic Island initiative?** Hekkert et al. (2011) proposed that the functioning of an innovation system needs to be assessed by experts or key stakeholders that are active in the system. Since each region and technology has its own characteristics, it is impossible to determine the ideal configuration of the system and consequently evaluate it by quantitative criteria. Therefore, assessment by involved parties is necessary.

The outcome of functional analysis is identification of function that can form obstacle to the system development, as suggested by Hekkert et al. (2011). Discussion of the sufficiency of activity in the area defined by function are based on the assessment in the context of achieving 95% electrification in 2020. Afterwards, the performance of each function will be examined by looking at each system structure in order to answer the main research question: **What are the systemic problems of Sumba Iconic Island initiative with regard to enterpreneurial activities, knowledge development and diffusion, and mobilization of resources?**

4. 1. Entrepreneurial activities

According to Sumba energy supply plan, almost a half of required funding to achieve electrification ratio comes from private sector activities. This is why function entrepreneurial activities is considered one of the most important function in Sumba Iconic Island. The real implementation of renewable energy plans and electrification growth has been a concern for some stakeholders. Hivos as the connecting stakeholder concludes that from the project's experience, there are several main considerations of private sector investment in Sumba Island as follows:

1. Potential of renewable energy sources
2. Sufficiency of feed-in-tariff to ensure the commercial viability of the project
3. Rough estimate of investment, in particular related to its location in Eastern Indonesia that generally requires significant upfront cost[16]

4.1.1. Sufficiency of amount and type of activities of the actors

Hekkert et al. (2007) explains that entrepreneurs include new entrants with vision of business opportunities in the new market or incumbent companies intending to diversify their business strategy. Their risky experiment is needed to tackle substantial uncertainty arising from new combination of technology (renewable energy), market (Sumba Island as an area in Eastern Indonesia with is considered not well-developed), and application (to increase electrification ratio). Renewable energy installations in Sumba are built by multiple actors, namely central government, regional government, PLN, private sector, and donor agency (including private sector through Corporate Social Responsibility scheme). In energy supply plan, the financing sources are differentiated to public and private. "Public" includes projects that would be financed by central

[16] Skype interview Hivos

government, regional government or PLN. The respective sources of funding are state budget, regional government budget and PLN's budget. All "Public" projects will be operated by PLN (Castlerock, 2015). For the purpose of this analysis, entrepreneurial activities function that will be examined is limited to private sector investment.

Realizing the need for private sector engagement, Hivos has been conducting effort for private sector scouting and matchmaking, among others through Sumba Investment Forum[17]. This forum facilitates the meeting between PLN, government, private sector, and financial institutions. The first forum was done in 2015 with the participants from existing Independent Power Producer and potential investors. A written guideline for investment explaining permit and licensing procedures was not available in time of this research, hence the companies could only refer to Sumba Iconic Island Roadmap and Blueprint[18]. The guideline was still being developed as a part of promotional pack for the next Investment Forum, scheduled in September 2016.

One of the challenges for private sector involvement is the interest to invest in small renewable energy potentials[19]. A great number of renewable energy potentials in Sumba Island are considered small with the capacity below 100 kW (PLN a, 2016). Independent power producers mostly prefer to tap into more well-developed areas that are consequently easier to penetrate, such as Java Island and Bali Island on the western part of Indonesia. Most independent power producers operate in Eastern Indonesia tends to prefer bigger scale investment (5 - 10 MW) than smaller ones (500 kW to 1 MW) considering the worth of its return of investment. Furthermore, a lot of bigger projects had been tapped by PLN[20] as the de facto provider of rural electrification; it has the mandate to electrify areas requiring great effort to attract private investment.

Another consideration for private sector to prioritize their investment is the clarity of feed-in-tariff (FIT) scheme[21]. As explained in Chapter 3, the only certain renewable energy FIT is for hydropower, thus hydropower is the resource that has been drawing the most private sector investment in Sumba Island. Microhydro projects built by independent power producers are in Praikalala 1 (capacity 2 x 300 kW) and Praikalala 2 (capacity 2 x 350 kW), Lapopu 1 (capacity 2 x 800 kW) and Lapopu 2 (capacity 2 x 400 kW), and Peduhunga (capacity 2 x 800 kW)[22]. Regarding solar energy, in 2015 PLN signed power purchase agreement with PT. Buana Energi Surya to build 1 MWp power plant in Sumba Timur district. This independent power producer will develop the solar power plant in cooperation with Conergy[23].

[17] Skype interview Hivos

[18] Skype interview PT. Nagata Bisma Shakti. Nevertheless, their active participation in stakeholder meetings helped to discuss any project issues with other stakeholders.

[19] Skype interview Hivos

[20] PLN has 1000 Islands Solar Power Plant development plan in Nusa Tenggara Timur province, with the total capacity for Sumba Island is 5,925 MWp (PLN, 2016).

[21] Skype interview Hivos

[22] PLN a. (2016). Potensi EBT dan Jardis se-Sumba [Potential of renewable energy and distribution generation in Sumba]. [Presentation files]. Presented on Sumba Area – Sumba Iconic Island Coordination Meeting 24 – 26 February 2016.

[23] CNN Indonesia. (2015, August 20).

On PLN side, PLN Sumba Area already established the roadmap of electricity and interconnection development until 2020[24], which also serves to inform interested companies. Equally meaningful effort to increase investment is by increasing the quality of infrastructure that in turn can facilitate accessibility of renewable energy installation[25].

The most compelling lesson learned on private sector involvement in Sumba Iconic Island emerges from PT. Nagata Bisma Shakti during the interview. PT Sumberdaya Sewatama, an incumbent player in electricity market, established Nagata in 2010 to show its commitment to develop renewable energy with independent power producer scheme. Nagata was initially interested with Sumba Island's big potential and they wanted to expand their business experience there. In 2012, this company started working with Hivos and Winrock to prepare the development of a 850 kW wind power pilot project in Haharu, Sumba Timur. This project will represent Nagata's foray into wind energy. Since at that time there was no commercial wind power project in Indonesia, to reduce its capital cost this project will be developed with Danish International Development Agency (Danida) grant. The grant was planned to be channeled through a local government-owned company. Danida was interested to join this project due to the strongly-developed wind power technology in Denmark. In this cooperation, Vesta will supply a refurbished wind turbine whereas Danida will fund the viability gap. It is projected that after the pilot project is running, Nagata will conduct study on its performance and tariff before moving to commercial, big-scale operation of 4 MW wind power installation[26].

As the project progressed, it was discovered that the logistical cost may escalate due to physical challenges, such as the need to disassemble crane because the insufficient port capacity and the need to move house to allow crane transportation. Other factor that contributed to the cost escalation was the very limited crane availability in Southeast Asia and low local content of wind turbine[27]. Concurrently, it took a long period of time to issue wind power feed-in-tariff regulation. This uncertainty made Nagata freezes its investment plan in 2014. In the future, Nagata might be involved in renewable energy generation in Sumba with hybrid solar PV and diesel generator, until the investment climate for wind power gets better. Nagata is currently exploring the potential to collaborate with wind turbine manufacturer from United States, since Millennium Challenge Account/USAID has recently been involved to provide grant for Sumba Iconic Island[28].

Besides Nagata, Hivos has been trying to engage foreign companies through cooperation with Indonesian partner companies. This effort also did not run well because those companies experience uncertainty about when the project can take-off and project feasibility related to the feed-in-tariff regulation issuance.

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[24] Email interview Ministry of Energy and Mineral Resources

[25] Email interview Provincial Mining and Energy Agency (Nusa Tenggara Timur)

[26] Investment plan and progress report of this project was supplied by PT. Nagata Bhisma Sakti during and after the interview

[27] Skype interview PT. Nagata Bisma Shakti. The wind turbine local content figures at that time was 10% and this made the price affected significantly by strength of foreign currency (US dollar). In fact there were several options that may increase the local content, such as the turbine manufacture to grant license to local engineering and procurement companies, but the requirement was not possible to meet for the context of this pilot project. There is domestic capacity to manufacture blade for wind turbine but again the cost was considered too high.

[28] Skype interview PT. Nagata Bisma Shakti.

The project developer regarded that renewable energy project is technically feasible yet not economically and environmentally feasible due to the shortage of central government support. Incentive scheme and pricing policy tend to be based on other countries' practices, without proper consideration of applicability to Indonesian islands with significantly different climate characteristics and farming method[29]. The forecasted pricing at that time (about 20 cents/kWh) is considered unattractive[30]. Entrepreneurs need a more thorough support to develop this new business area such as initial risk-sharing scheme, before moving on to tariff negotiation once the project is optimized and studied further[31].

Up to now, another company that will invest in Sumba Island is PT. Len Industry. This company has signed the cooperation agreement with Sumba Barat district government in April 2016. The cooperation includes location survey, data collection, feasibility studies, and setting up of Detail Engineering Design and business plan before building solar power plant with the capacity of 5 MW. This solar power plant will supply the electricity to the system which peak load of 6.5 MW (combined with Sumba Barat Daya district). However, there seems to be a challenge related to regulation of electricity sale to PLN. PLN can purchase only 10% of generated capacity, which brings uncertainty about the rest of the generated capacity. The local government had not been aware of this regulation before it was brought up to stakeholders meeting[32]. Regulation disharmony also occurred between ministries. This happened when PLN planned to build microhydro power plant in Sumba Barat Daya District, and needed permit from Ministry of Forestry and Environment. This licensing issue has put the project on hold for two years without a clear solution[33].

It is worth pointing out PLN's plan to build a 10 MW gas machine power plant in Tambolaka, Sumba Barat Daya. The power plant is planned to operate by 2019 and most likely will help boost overall electrification ratio, despite straying from the ideal approach of prioritizing the use of renewable energy sources.[34]

4.1.2. Score of this function

Hekkert et al. (2011) suggest that the prime indicator of fulfillment of this function is presence of active entrepreneurs in the system, which for this analysis is limited to private sector. This indicator is relevant because the more active entrepreneurs investing in renewable energy projects, the more energy installations will be developed, which subsequently will be beneficial to supply electricity to reach more population in the island.

How Sumba Iconic Island presents a big opportunity for investment is stated by interviewee from central government. The company verified this, as they recognized the opportunity to build new

[29] Skype interview PT. Nagata Bisma Shakti.

[30] Skype interview PT. Nagata Bisma Shakti. With this in mind, on the recent draft feed-in-tariff regulation currently being discussed by MEMR, the purchase price is 16.4 cents US$/kWh for region I (interconnected network system in Java, Madura, Bali and Sumatra), 15.7 cents US$/kWh for region II (interconnected network in Kalimantan, Sulawesi, West Nusa Tenggara and East Nusa Tenggara), and 28 cents US$/kWh for region III (interconnected network system Papua, West Papua, Maluku, North Maluku, and off-grid systems in all regions). Being off-grid system, Sumba is classified in region III.

[31] Skype interview PT. Nagata Bisma Shakti

[32] Skype interview Sumba Barat Daya Mining and Energy Agency

[33] Skype interview Sumba Barat Daya Mining and Energy Agency

[34] Skype interview Sumba Barat Daya Mining and Energy Agency

business profile in renewable energy there. Nevertheless, the high opportunity for investment does not translate well into the similar extent of interest. All interviewees from regional government said that on the ground they observe very little interest from private sector to invest.

The positive link between incentives for innovation and entrepreneurial activities is suggested by Hekkert et al. (2007). In terms of supporting facilities, all interviewees from government office informed that local government provides facilities as well as ease of getting business permit. This is confirmed by the company that experienced ease in land provision and no obstacle in obtaining principle permit. Provincial government reported to have been improving infrastructure that can indirectly influence level. However, an interviewee from district agency mentioned cases where disharmony between regulations created project license/permit issue.

In terms of financial incentives, government grants feed-in-tariff for microhydro, and is currently reviewing feed-in-tariff for biogas, biomass, and solar PV. The significant gap in regulation is feed-in-tariff wind power that was proposed to be a major showcase project in Sumba Iconic Island. Hydropower, being the only resource with a certain feed-in-tariff, has been drawing the largest private sector investment in Sumba. The company interviewed for this research assessed that support from central government is lacking, particularly for wind power development.

In line with the opinion of the interviewees, and combined with the above mentioned findings, this research suggests that the function entrepreneurial activities might be problematic and hamper the achievement of Sumba Iconic Island target. With attention to the need to catch up the rest 53% electrification ratio in less than 5 years, more business activities are required to increase private sector experience and level of investment. Since the prime indicator of fulfillment of this function is presence of actors in the system (Hekkert et al., 2011) this research evaluate entrepreneurial activities at the level of weak.

4. 2. Knowledge development and diffusion

Bergek et al. (2008) distinguish different types of knowledge (scientific, technological, production, market, logistics and design knowledge) and different sources of knowledge development (research and development activities, learning from new applications and production, and imitation). The developed knowledge is diffused in the system by available networks. Knowledge exchange, taking place in the process of interaction, is imperative for the build-up of the system. In emerging system the interaction takes the form of bi- and tri-lateral collaborations (Luo et al., 2012).

This section will map the effort put into knowledge development over time (Hekkert et al., 2007) by looking at the number of research and development activities and the type of actors involved. This section will also examine the knowledge exchanged between different actors' group by looking at the number of capacity building activities and try to gauge general accessibility of knowledge. The findings are complemented by interviewing actors about whether or not there is enough beneficiaries' interest to learn about renewable energy and level of understanding about renewable energy. These are important with regard to the newly introduced technology that requires the responsibility and capability of beneficiaries to maintain once it is installed.

4.2.1. Sufficiency of research and development activities

Hivos invested time and resources to build a solid knowledge base for intervention in Sumba Island (Hivos, 2015). Renewable energy planning is supported by existence of various planning document and renewable energy potential map. In 2011, KEMA did a research on options for on-grid generation and Roman Ritter studied options for off-grid generations, including about source of financing. These studies help convince investors that the Iconic Island is backed by solid research. Additionally, there were several research focused on a particular renewable energy source potential. In 2013, ADB through Castlerock Consulting started to scrutinize and capture the location and potential of each sources of renewable energy suitable for grid supply[35], including energy demand analysis and willingness of local residents to pay for electricity. The input of this study was used to explore how those resources may be developed on a least cost basis and estimate the corresponding cost of required on-grid and off-grid infrastructure, which resulted in Least Cost Electrification Plan in 2014. The findings the study done to construct the plan was then utilized to build a year-to-year electricity supply investment plan. Hivos has been communicating the feasibility studies to private sector. These studies played an important role in providing credibility and ensuring stakeholders that interventions are based on proper assessment of feasibility (Hivos c, 2015). The table below explains the number of research done for the purpose of developing Sumba Iconic Island knowledge base.

Table 4-1 List of research supporting the renewable energy planning of Sumba Iconic Island

No	Research	Institution/Researcher	Time
1	'Iconic Island Preliminary Scoping Report' identifies various island candidates in Indonesia	Hivos	2009
2	'Fuel Independent Renewable Energy Iconic Island' as a preliminary assessment resources of Sumba Island and Buru Island	Winrock International	2010
3	'Scoping Mission on Off Grid Electrification' identifies solar PV and hydro options	Roman Ritter	2011
4	'Grid connected electricity generation' identifies possible grid connected solutions	KEMA Nederland BV	2011
5	'Feasibility of Biogas in Sumba'	SNV Netherlands	2011
6	'Small Scale Hydro Power for Grid Connection on Sumba Island' as an initial site assessment	PT. Entec Indonesia	2011
7	'Plants for Power: The potential for cultivating crops as feedstock for energy production in Sumba'	Jacqueline Vel & Respati Nugrohowardhani (Univesity of Leiden)	2012
8	'Socio-Economic-Gender Baseline Survey'	JRI Research	2013

[35] Skype interview Hivos

No	Research	Institution/Researcher	Time
9	'Sumba Energy from Waste'	Fact Foundation	2013
10	'Energy Resources for Grid Supply & Electricity Demand Analysis for Sumba'	Castlerock Consulting	2014
11	'Least-Cost Electrification Plan for the Iconic Island'	Castlerock Consulting	2014
12	'Inputs to the Sumba Iconic Island Road Map'	Castlerock Consulting	2015

Reference: Each study report and Hivos. (2015). A Case Study of the Multi Actor Sumba Iconic Island Initiative.

There is small number of collaborations done between Hivos and universities or research centers. Nusa Cendana University, a university based in the Province's capital, has been involved in regular stakeholders meeting. Hivos deliberately limits university collaboration to the university close to its project area. Collaborations with research center were done with public research organizations, such as Indonesian Institute of Science *(Lembaga Ilmu Pengetahuan Indonesia)*, Agency for Assessment and Application of Technology *(Badan Pengkajian dan Penerapan Teknologi)*, and Ministry of Energy and Mineral Resources' own R&D Agency. Those are mostly focused on renewable energy potential. Collaborative researches were also done between US National Renewable Energy Laboratory (NREL) and Winrock International. Up to now, there is no collaboration between private sector and university that is done for the purpose of supporting the implementation of Sumba Iconic Island[36].

4.2.2. Sufficiency of networks through which knowledge can diffuse

Knowledge diffusion in Sumba Island

Knowledge diffusion in Sumba Iconic Island comprises of dissemination of information inside and outside project area. Inside the project area, the dissemination of information mostly takes place through capacity building activities. Among the island population, not all of them can be categorized as project beneficiaries. Latest data from PLN shows that from among 426 villages, only 176 villages have electricity access, or around 41% of the whole island (PLN b, 2016). This number can be an indication of how much knowledge about renewable energy had been spread in the island. Awareness towards the benefits of using renewable energy installations (such as SEHEN, biogas, and biofuels) for increasing the beneficiaries' quality of life and their family income is required to boost their participation in development and operation of those renewable energy installations (JRI, 2013).

Sumba Island lies in Nusa Tenggara Timur Province, which is still grappling with high poverty. In comparison of average poverty level in Indonesia from 2007 to 2011, this province has the average poverty level of 23,37% - coming in third of poorest provinces in the archipelago after Papua and Mollucas (Amelia, 2012). In relation to that, the level of completed education is also low. The relatively low level of education affects the low knowledge about renewable energy. This is complicated by the fact that the four districts have different background with their own social

[36] Skype interview PT. Nagata Bhisma Sakti

setting and custom, thus requiring different approach[37]. Given these point, carrying out knowledge diffusion inside Sumba Island is not a simple task. In spite of the endeavors to increase awareness and knowledge that had been done, all interviewees inform that there need to be more awareness raising and capacity building activities.

Interview with the stakeholders show that there is still limited understanding of renewable energy, although project beneficiaries experience better understanding than local residents who have never received the program. This relatively limited knowledge sometimes leads to lack of project maintenance. Although Hivos considers that there is a high number of operators committed to maintain the installation, the local resident and district governments reported that there are a lot of cases where installations are broken down due to lack of maintenance (especially that of Solar Home Systems). As a matter of fact, this also occurs because local residents do not earn enough compensation from maintenance activities, thus they perceived that their time would be better invested in other income-generating activities[38]. One local resident informed that continuous knowledge diffusion activities are needed to change the behavior from solely receiving the program towards a more empowered attitude[39]. It is also observed that the beneficiaries have limited understanding of the sources (renewable energy), what they actually need is the services provided by the sources, namely the electricity especially for lightning and supporting home industry activities[40].

Knowledge about renewable energy is diffused through formal and informal network. Knowledge dissemination activities to beneficiaries depend on what party is doing the installation. For example, before building installation with state or national budget, there is the mechanism to establish a Local Community Organisation *(Organisasi Masyarakat Setempat)*. This organization appoints administrators for project management and sustainability[41]. During this process, local governments disseminate information about the project and the resident's rights and obligations. Hivos supports this preparation by conduct needs assessment, village meetings, capacity development and community organizations – in which they learn to organize themselves, construct the rules of organization, and agree on the amount of community contribution once the project is installed. These activities are done in cooperation with several local civil society organizations such as Yayasan Sosial Donders, Yayasan Alam Lestari and Yayasan Sumba Sejahtera.

Regarding capacity building activities, Hivos did a workshop for solar and microhydro power plant maintenance, but it has not covered all operators in Sumba Island[42]. The objective for such workshop is indispensable, because the participants are expected to be a driving force in their village comunities[43]. Hivos also conducted energy planning training for local government officers and gender training program for local civil society organizations related Sumba Iconic Island implementation. Ministry of Energy and Mineral Resources carried out community capacity building

[37] Skype interview Hivos and Sumba Barat Daya Mining and Energy Agency
[38] Email interview Sumba Tengah Mining and Energy Agency
[39] Skype interview chief of Koperasi Jasa Kasih in Kamanggih village
[40] Email interview Sumba Tengah Mining and Energy Agency
[41] The formulation of Local Community Organisation with is obliged for grant receiver from regional budget, as stated in Minister of Interior Regulation 32/2011 (Amended by Minister of Interior Regulation 39/2012).
[42] Skype interview Hivos
[43] Skype interview Sumba Barat Daya Mining and Energy Agency

workshops for all renewable energy-based operators in Indonesia, in which operators in Sumba were enrolled. To cater the various existing needs for Sumba Iconic Island, this ministry planned a series of workshop to hold next year[44]:

- Operation and maintenance workshop for all operators
- Energy policy, planning and budgeting to strengthen local government's capacity
- Capacity building for local government-owned company to manage renewable energy installation

Additionally, mass communication is also done inside the island, performed through cooperation with Max FM in Sumba Timur and Fox Mundi FM in Sumba Barat Daya. These two local radio stations regularly spread the information about project update to their listeners[45]. These radio stations also attend stakeholder meetings and since 2013 two journalist has been contracted as local reporters to write stories on Sumba for Hivos site (Hivos c, 2015).

Informal network, or casual transfer of information, also plays an important role especially when preparing to build renewable energy installation. It does not only happen through formal village meeting, but also through cultural events where the community frequently gathers such as wedding ceremonies or funeral celebrations[46]. This helps build a sense of belonging from the start, so that the community is committed in taking care of the surrounding forest and environment, alongside the effort to maintain the installation[47].

Knowledge diffusion for general public

Information dissemination outside the project area occurred through workshop, conferences (such as the annual EBTKE conference and exhibition and Energy Forums), promotional activities, and also development fairs where local governments participate. Iconic Island campaign was also done to generate public awareness on renewable energy, climate change, and energy access in the Netherlands and Indonesia. There has been a lot of positive coverage of Sumba Iconic Island in media and in a way it encourages replication in other initiatives, such as Bright Indonesia Program[48]. The campaign and coverage reinforced the role of Hivos, and the commitment of government and PLN to the initiative (Hivos c, 2015).

Nevertheless, Hivos recently has slowed down the promotional activities, because the more urgent priority is to boost the implementations of renewable energy plans[49]. Hivos focuses its resources to approach business sector and small/medium enterprises that can expedite more significant implementation. Regardless of that, the accumulated knowledge from various studies is available and easily accessed in Sumba Iconic Island website. The studies will be valuable as preliminary information for any party with interest to be involved in this initiative. A geographic information system map explaining resource locations, grid demand, existing and proposed network, and

[44] Email interview Ministry of Energy and Mineral Resources
[45] Skype interview Hivos
[46] Skype interview chief of Koperasi Jasa Kasih in Kamanggih village
[47] Skype interview chief of Koperasi Jasa Kasih in Kamanggih village
[48] Skype interview Hivos
[49] Skype interview Hivos

population distribution is also available online as 'a public service and public resource of general information'[50].

4.2.3. Score of this function

Hekkert et al. (2011) suggest diagnosing whether or not there is sufficient amount and sufficient quality of knowledge development for the development of innovation system. It is also suggested to diagnose whether or not the type of knowledge developed fit with the knowledge needs; and if the quality and/or quantity of knowledge development form a barrier to the innovation system to move to the next phase (in this context it will be take-off phase).

As displayed in Table 4.1., there is sufficient amount and well-linked research and development activities to build a strong knowledge base for renewable energy planning. Earlier technology studies and renewable energy projects (PV project, mini grids, PLN's energy efficient lamp, and district government's solar home systems) were beneficial to understanding the context and gaining experience (Castlerock,2014). It then progressed into the study capturing all potentials in order to build least cost electrification plan that was among the first of its kind conducted in Indonesia (ADB b, 2016). The electrification plan was developed further to create 'Investment Plan on Renewable Energy Projects Development by 2025'. This investment plan was used as an input for Sumba Iconic Island Roadmap.

The role of feasibility study is to help potential investors in making investment decisions, such as on feasible locations to start the project[51]. This in turn will facilitate the entrance of new investment, for example the one year wind resource survey implemented by Winrock International was used to develop wind farm proposal for Nagata's project (ADB, 2016).

The produced knowledge is considered to be well-aligned with the needs of each development. As an illustration, after it is mandated in 2015 to accelerate Sumba Iconic Island's target[52], Castlerock formulated three energy supply scenarios scrutinizing timing and level and investment to meet each target. These scenarios further enabled stakeholders to discuss and determine the next relevant strategy. Alignment with needs also seen from study aimed for specific project preparation; such as the study exploring impact of integrating wind pilot turbine to eastern Sumba power system network done by NREL, wind measure assessment by NREL, and storage hydro assessment done by AFD.

What is still needed to be done in terms of knowledge production is the continuation of the research activity, considering that ADB (as an important source of research support) has finished its assistance in the end of 2015. ADB's last report 'Inputs to the Sumba Iconic Island Road Map' provides first-order estimates that in fact should be confirmed through additional studies (Castlerock, 2015). Additionally, related to the original purpose of conducting research to create a solid knowledge base, there is the need to incorporate the findings of the produced knowledge into the overall planning. For example, Castlerock's 2014 study had anticipated that the availability of

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50 The GIS map address is http://castlerockasia.com/sumba/sii.html

51 Skype interview PT. Nagata Bisma Shakti.

52 MEMR Regulation no 3051 K/MEM/30/2015 stipulate Sumba as Renewable Energy Iconic Island. This regulation is issued after the Minister conduct a field visit to the island to monitor the implementation and progress of Sumba Iconic Island.

capital investment would likely to be problematic, thus in such a case the Sumba Iconic Island target may be relaxed to a level that can be accommodated by the available investment. The adjustment of target according to potential amount of investment did not take place, on the contrary, the target was accelerated and it put more pressure to the effort of realizing renewable energy plans. Equally important is the need to comprehensively update the Roadmap using the result of the study to reflect the new accelerated target (95% electrification ratio by 2020) and clarify how the target should be met by all stakeholders, including identification of responsible party for each activity.

Hekkert et al. (2011) suggest that the prime indicator of knowledge diffusion is type and amount of networks. Although the amount of available network is sufficient, all interviewees emphasize the importance of continuous capacity building and awareness building activities in the context of Sumba Iconic Island, and they acknowledge that there has yet enough done for the purpose of project maintenance. In view of this discussion, this research evaluates knowledge development and diffusion at the level of moderate. This assessment also takes into consideration Hivos' recent refrain from outside promotion and collaboration, apart from those aimed at private sector.

4. 3. Resource mobilization

This function comprises of allocation of financial, material (including natural resources), and human capital in order to develop the implementation of Sumba Iconic Island. Resources are needed as a basic input for all activities in the system, and without resources system are unable to function. Particularly, a specific technology may need allocation of sufficient resource (Hekkert et al., 2007). The relevance of mapping resource mobilization arises further in relation to the fact that 95% electrification ratio by 2020 requires 2.5 times as much energy as the business-as-usual case. This figure was calculated by Castlerock in Sumba energy supply plan. This part will delve into the availability of financial resources, human resources, and physical resource (natural and infrastructure) to meet the above objective. Hekkert et al. (2007) suggested exploring whether or not inner core actors perceive access to sufficient resources as problematic.

4.3.1. Availability of financial resources

Sumba Iconic Island initiative requires huge amount of financial mobilization, in particular considering that the end target year is getting closer. Achieving 95% electrification ratio by 2020 will need as much as 428.4 million US$. The number comprises of 105,3 million US$ private generation; 210,6 million US$ public generation (a huge percentage of this number is for network expansion); 84,7 US$ dam type hydro power plant; and 27,9 US$ off-grid and mini grids (SII Secretariat, 2015). The last two items are not assigned to either private or public because it can be developed by both sources of funding.

All levels of governance (district, provincial, and central) allocate their own budget for Sumba Iconic Island. Without specifying the amount of recent allocated budget, all agencies interviewed admitted that public budget limitation becomes an obstacle to speed up electrification ratio. Relying on state budget will not be enough because of the limited amount is not comparable with the vastness of the area needing electricity[53]. An officer from a district mining and energy agency illustrated the big gap between recent electrification ratio in the district and the targeted

[53] Email interview Ministry of Energy and Mineral Resources

electrification in 2020: it will require 14% increase of electrification ratio at the annual rate; thus the limited budget will make it very hard to accomplish the target.

Achieving the SII targets depends strongly on rate of PLN connections. Rate of PLN grid extension will determine electrification ratio and generation needs, namely share of supply that can be served by renewable energy sources (Castlerock, 2015). Allocation of PLN funding for Sumba Iconic Island is not accessible by this research, however, PLN's national business plan acknowledged that its general internal funding ability is really low. This is because PLN was unable to gain margin of public service obligation before 2009, thus all investment is funded by debt[54]. It is unlikely that PLN will budget network extension with its own research and it could be financed by state equity capital mechanism or directly by multilateral or bilateral agency[55]. Dam micro hydro power plant projects are assumed to be built both by PLN and private, grid connected wind and solar PV project are assumed to be built by private developer. Biomass project is proposed to rely on private developer. It is also proposed to utilize private sector involvement for off-grid generation[56]. Given these points, private sector investment and mobilizing external funding from donor agencies is crucial.

In Indonesia, public funding for renewable energy only include the investment in technology procurement; excluding the effort to prepare institutions and operation and maintenance after the project is due[57]. This is also the case in Sumba, with no budget for maintenance given for the project[58], thus the maintenance budget has to be set separately. However, it is found that maintenance and training cannot be properly allocated due to the budget limitation[59]. One example is there were annual workshop carried out for Solar Home System and SEHEN light repair given for grant receiver. The workshop was stopped two years ago because of budget limitation while the Solar Home System and SEHEN installation is still provided each year, by regional government and PLN respectively, in spite of the required amount of money need to hold the workshop being not high[60].

The company interviewed for this research, initially intended to build wind power pilot project, informed that there was a challenge in meeting the project capital cost. Some of the project component was planned to be covered by grant to lessen the capital cost[61]. However, while deliberating the project financial structure with the potential grant provider, it is discovered that

[54] PLN's electricity supply business plan 2016 - 2025

[55] Castlerock Consulting. (2015). Inputs to the Sumba Iconic Island Road Map.

[56] Castlerock Consulting. (2015). Inputs to the Sumba Iconic Island Road Map.

[57] Institute for Essential Services Reform. (2015). FGD#2 Pendanaan energi berkelanjutan di Indonesia [Sustainable energy financing in Indonesia. Retrieved online from http://iesr.or.id/2013/08/fgd2-pendanaan-energi-berkelanjutan-di-indonesia/. Accessed in 30/9/2016.

[58] Skype interview Sumba Barat Daya Mining and Energy Agency. This district level agency is in charge for regular monitoring for all renewable energy installation. In the case of light breakdown of decentralized solar power, this agency can handle light repair, but for more serious ones it has to wait for the disbursement of Vilage Electrification Special Allocation Fund *(DAK Lisdes)* from central government.

[59] Email interview Provincial Mining and Energy Agency and Skype interview Sumba Barat Daya Mining and Energy Agency

[60] Skype interview Sumba Barat Daya Mining and Energy Agency

[61] Some regulations related to grant provision also became a consideration for this project; for example, the grant provider cannot directly allocate fund for project developer but through a local-government owned company instead, and the project will use refurbished turbine and thus will be subjected to time usage limitation, according to the refurbished component regulation.

this project will be a loss maker[62]. Completed with absence of wind feed-in-tariff, the project was on hold in 2014. The internal rate of return (IRR) for this investment is also still low at the level of 10%, considering it will be more attractive and economically feasible if the IRR can achieve 13-14%[63].

Renewable energy generation projects are relatively new business area for private sector in Indonesia. It did not start before the introduction of feed-in-tariff in 2009. Therefore, there is a lack of familiarity of technical and financial aspect for financing renewable energy. Commercial banks apply slightly higher interest rate because the unpredictable nature of renewable energy projects relying on natural resource increases its perceived risk. For example, fluctuating stream flows in small hydropower projects make revenue calculation and financial analysis more speculative and risky in their perspective (Cameron and van Tilburg, 2016).

The majority of independent power producers in Indonesia experience difficulties in securing appropriate debt financing for renewable energy projects, due to the following reasons:

1. Commercial banks apply the same procedures and requirements for renewable energy project as for conventional projects. It means that the loan required directly accessible collateral of 100% or more of the project value, loan tenors are short, and with no fixed interest rate. These stringent lending conditions mean that obtaining loan is only possible for companies with strong financial support.
2. The actual IRR often drops because of many of the projects finances experiences cost overruns.
3. Developers need to prepare a significant upfront equity because bank loans cannot be used for project preparation activities and land acquisition (Cameron and van Tilburg, 2016).

4.3.2. Availability of competency and expertise

The availability of expected competency and expertise in Sumba Island seems to be in short supply. There is a lack of human resources with sufficient expertise on renewable energy in local government agencies[64]. Outside of PLN and Mining and Energy Agency's staffs, there is very limited education regarding renewable energy, also considering the general low level of education in Sumba. The community is considered as agriculture society with innate unfamiliarity with utilization of modern technology[65]. The agricultural sector dominates Sumba's economy, it accounted for around 48% of the gross domestic regional product in 2008. The crops farmed by communities include food crops (rice, cassava, sweet potato) and cash crops (coffee, cashew nuts,

[62] Financial model in feasibility study used the current (2012) exchange rate of 1 US$=Rp 9500, whereas before the project development (2014), the exchange rate was weaken to 1 US$=Rp 13500. Because there was no feed-in-tariff regulation yet, the company calculated feed-in-tariff according to production cost, a practice that was commonly carried out by wind power developers in other project area. With the former exchange rate, the proposed tariff is 22 cents/kWh while with the recent exchange rate it is increased to 28 cents/kWh.

[63] Analysis of William Sabandar (Chief of Renewable energy acceleration task force – Ministry of Energy and Mineral Resources) referring to this wind pilot project. CNN Indonesia, (2016, August 29).

[64] Skype interview Sumba Barat Daya Mining and Energy Agency. Also Ritter (2011) in the discussion of possible financial sources for off-grid electrification, mentioned that to get Special Allocation Fund, the district government usually do not have enough experience to compile good feasibility study as a requirement to be granted the fund.

[65] Email interview Provincial Mining and Energy Agency

coconut) (Hivos a, 2012). More than a half of female and male population only finishes primary school education according to the project baseline survey (JRI, 2013).

Additionally, there are in fact vocational high schools *(Sekolah Menengah Kejuruan)* with electricity major that may be a suitable means to learn about renewable energy. Although they indeed offer classes on renewable energy, the students' interest in learning is really low. The available classes or programs are considered not enough for continuation of capacity building in longer term[66].

4.3.3. Sufficiency of physical infrastructure

Physical infrastructure was one of the main considerations when Hivos set up the Iconic Island concept through preliminary resource assessment of two candidate islands, Sumba and Buru Island, to determine which one is more compatible. Sumba's infrastructure and ease of journey from the country's capital fared better than Buru Island. Recently, main roads in the entire island are considered in a good condition, particularly by Eastern Indonesia standard. There are also good access roads at least to all community's activities center that is understood as capital of counties/*kecamatan*[67]. The ports are assessed to be operated quite actively.

Nevertheless, there are several limitations when it comes to the logistics of renewable energy installation. When planning to develop wind power pilot project, port capacity limitation increases transportation cost due to the need to disassembly parts[68]. The available port is only suitable for ferry to moor, not for large ships transporting containers[69]. Sumba's geographical characteristics, consisting mostly of hilly terrain with a number of winding roads, will hinder the installation of wind turbine above 500 kW capacity[70].

The highly sparse population of this island accounts for dispersed settlements and limited access roads that in turn affect the provision of grid and personnel/equipment mobilization[71]. Suitable roads are important for transporting solar panel (which is the best option for off-grid generation) to the villages, yet sometimes the village roads are not even good enough for its transportation. Some settlements are only reachable by footpath. For hydro power installation, in some cases in more remote areas, additional infrastructure construction is needed to reach its source[72].

Decision making in building local renewable energy is largely influenced by this lack of infrastructure. Stakeholders tend to prioritize building renewable energy project in the village with good accessibility[73]. In terms of PLN grid stability, the company interviewed informed that the vulnerability to grid disruption pose as a weakness of their project[74].

[66] Skype interview Sumba Barat Daya Mining and Energy Agency
[67] Email interview Provincial Mining and Energy Agency
[68] Skype interview PT. Nagata Bisma Shakti
[69] Skype interview Sumba Barat Daya Mining and Energy Agency
[70] Email interview Ministry of Energy and Mineral Resources
[71] Email interview Provincial Mining and Energy Agency
[72] Skype interview Hivos
[73] Skype interview Sumba Barat Daya Mining and Energy Agency
[74] Skype interview PT. Nagata Bisma Shakti

4.3.4. Availability of natural resource

Castlerock published a report in 2014 focused on renewable energy resources suitable for grid supply. It calculated the maximum amount of resources that is technically available for utilization. The report pointed out several constraints to the technical potential. Firstly, resource availability was identified for three kinds of hydropower, due to the large seasonal variability. It was also identified for biomass, because only forest plantation can produce sufficient number of biomass for a meaningful contribution to energy need. Secondly, system operation limitation was identified for solar PV and wind; which means that despite the unlimited physical availability, the technical potential is constrained by the need to maintain grid stability. In the final analysis, this report suggested that while Sumba owns abundant renewable resources, seasonality of these resources will remain a challenge to achieving the Iconic Island target of 100% renewable energy supply.

The result of this report is used for input in least-cost electrification planning exercise. The modeling indicates that the objective of 100% renewable energy supply together with 95% electrification ratio by 2025 will be difficult to achieve in the absence of reliance on biodiesel. Nevertheless, there is potential to supply as much as 90% grid supply from renewable sources, on the condition that substantial investment in generating capacity is available (Castlerock, 2014).

4.3.5. Score of this function

The prime indicator of resource mobilization function is financial resources, human resources, and physical resources that comprises of material and infrastructure (Hekkert et al., 2011). The analysis deal with the sufficiency of financial and human resources and whether or not they form barrier to achieve the target; and whether or not physical infrastructure is well developed to support it. The closer, more thorough examination at the abundance of renewable energy sources shows that seasonality and system operation limitation might hamper the achievement of Sumba Iconic Island's target. Another negative point is the fact that core actors (PLN, private sector, and government agencies) do not find it easy to access financial resources. Sufficient human resources are also on short supply; and there are a number of physical challenges for carrying out renewable energy plans such as limited port capacity, geographical characteristics of the island, and insufficient access roads.

In the long run the circumstance of this function might complicate the system through interlinked issue. This is especially the case when limited financial resources can negatively influence other functions, such as the limitation of fund to implement showcase projects that otherwise can strengthen the function entrepreneurial activities, or budget constraint that can hinder knowledge development and diffusion activities. Based on this analysis, this research evaluates the function resource mobilization at the level of weak.

4. 4. Analysis of performance of functions

The table in the next page summarizes previous discussion about how well each system function performs. The positive and negative points highlighted in this table together construct the basis for calculating the score for each function.

Table 4-2 Score of system functions

Function	Positives	Negatives	Score
Entrepreneurial activities	• Investment Forum • The regular stakeholders forum can be used to discuss obstacles of project • Ease to get principal license from local government • Local government improve infrastructure that can indirectly increase investment	• Low presence of private sectors • Absence of financial institution to fund renewable energy projects • Not all sources of renewable energy has feed-in-tariff scheme • Absence of specific investment guideline • Government support in terms of renewable energy incentive schemes is considered insufficient • Disharmony of regulations can pose a problem • Low quality of physical infrastructure	Weak
Knowledge development and diffusion	• Sufficient research and development activities to provide a strong knowledge base • Sufficient amount of network • Identified interest, especially for project beneficiaries, to learn about RE • Opportunity for knowledge diffusion outside project area	• Varied understanding of renewable energy, in areas where it is limited sometimes leads to lack of installation maintenance • Not enough continuous capacity building activity for project maintenance • Hivos' lessening interest to collaborate with universities and research centers	Moderate
Mobilization of resources	None	• Presence of financial institutions as an important supporting actor for this function is minimal • Insufficient capacity to pool financial resources. Roadmap is not updated to reflect the accelerated target • Limited quality of physical infrastructure to solve physical challenges • Seasonality of natural resources and the corresponding system operational limitation • Limited quality of human resources	Weak

4. 5. Concluding result: Identification of systemic problems

Combining structural and functional analysis to investigate systemic problems is proposed by Hekkert et al. (2011), because functions that are not well-fulfilled are manifestations of problem in the structure. Obstacles in achieving Sumba Iconic Island's target can origin from the structure of the system. This analysis will point out which structural element causes the weakness of the function. In other words, it will discover whether or not the weakness of the function has something to do with actors, institutions, interactions or infrastructure. From a policy perspective, it is essential to understand the blocking mechanisms that prohibit good system functioning and shape the nature of functional dynamics (Hekkert et al., 2007; Bergek et al., 2008).

The next step is to explore whether the blocking mechanism occurs because any of these structure are missing *(presence problem)* or there is an issue with their capacity and/or quality *(capacity/quality problem)*. This analysis is carried out for all three functions in order to identify where exactly the problem is in the system structure. The final outcome is the identification of systemic problems.

First of all, this research evaluates the function 'Entrepreneurial activities' at the level of weak. More business activities are required to increase private sector experience and level of investment. The central indicator of how well this function is fulfilled is the presence of private sector in the system. The relevance of this indicator is because the more investment made the more energy installations will be built to serve more population. It will eventually help to achieve the target of increasing the electrification ratio of this island. It is observed that despite the abundant renewable energy potential available in Sumba, the level of investment needed to realize the potential (turning the renewable energy resources into electricity) is low. Linking the low investment, as the blocking mechanism, to systems structure results in identification of problems in the structure. The actor-related problem is the insufficient number of private sector involved. There is only a limited number of private sector investments. As a matter of fact, hydropower is only source of renewable energy that was able to attract a large investment, since it is ensured by a certain feed-in-tariff. This brings the discussion to institution-related problem. The absence of feed-in-tariff and other expected government support for private sector pose an obstacle for new investments to be made. Infrastructure-related problem contributes to the low investment, because the physical infrastructure needed for enabling renewable energy installation has poor quality. It increases capital cost of the projects and hampers project development.

Second, the function 'Knowledge development and diffusion' is evaluated at the level of moderate. A plus point is sufficient amount and well-linked research activities, and that they are well-aligned with the knowledge needs. The blocking mechanism is related more to the diffusion of the produced knowledge that eventually limits the success of well-distributed knowledge. Although the amount of available network through which knowledge can be disseminated is sufficient, they are not utilized as much as possible to ensure the participation in development and operation of renewable energy installations. This can be traced back to interaction-related problem. There is insufficient frequency of continuous capacity building and awareness raising activities. The institution-related problem is established practices and norms to maintain renewable energy installation that is in fact present, but it is considered insufficient. It also tends to vary between project areas with their own different background.

Finally, the function 'Mobilization of resources' is evaluated at the level of weak. There is a lack of actual financial resources that can be allocated to fund renewable energy installations and the supporting activities. Besides, the core actors experience obstacle to access financial resources. There is also a shortage of human resources. Furthermore, a large number of physical challenges have not been solved by enough infrastructure support. When looking at the corresponding structure, there are several reasons discovered as the cause of these blocking mechanisms. Actor-related problem is found in the insufficiency of the number of financial institutions or banks that can finance renewable energy projects. Additionally, the capacity of public and private stakeholders to pool enough financial resources for the purpose of increasing the implementation is insufficient. Institution-related problem is found in the insufficiency of the official document to guide the rest of the project implementation, since Sumba Iconic Island Roadmap and Blueprint is not revised to reflect the accelerated target. Another problem is infrastructure-related, namely the absence of several physical infrastructures and limited quality of the existing physical infrastructure to enable project implementation.

The summary of the completed analysis is presented in the table below for clarity.

Table 4-3 Identification of systemic problems

Functions	**Function evaluation**	**Reasons why the specific function is absent/weak/strong etc. ('blocking mechanism')**	**Systemic problems (presence/capacity/quality)**
Entrepreneurial activities	Weak	Low investment to realize the potential of renewable energy.	Actors: Insufficient number of private sector investment. Institution: Absence of feed-in-tariff and other expected government support for private sector. Infrastructure: Limited quality of physical infrastructure increases capital cost and hampers project development.
Knowledge development and diffusion	Moderate	Limited knowledge of renewable energy. The number of networks which knowledge can diffuse is sufficient, but they are not utilized as much as possible.	Institution: Established practices and norms to maintain renewable energy installation is present, but it is insufficient and tend to vary between project areas. Interaction: Insufficient frequency of continuous capacity building and awareness raising.
Mobilization of resources	Weak	Lack of actual financial resources and the low accessibility of financial resources for the core actors; insufficient human resources; plenty of physical challenges have not been solved by enough infrastructure support.	Actors: Very minimal number of financial institutions/banks as supporting actor. Insufficient capacity of public and private stakeholders to pool financial resources for the purpose of increasing the implementation. Institution: Sumba Iconic Island Roadmap and Blueprint is not revised to reflect the accelerated target. The only document guiding the rest of the project lifespan is energy supply plan. Infrastructure: Absence and limited quality of physical infrastructures.

CHAPTER 5. CONCLUSIONS AND RECOMMENDATIONS

The objective of this research is to investigate the problems occurring in the implementation of Sumba Iconic Island. It aims to find the answer to the question: What are the systemic problems of Sumba Iconic Island initiative with regard to entrepreneurial activities, knowledge development and diffusion, and mobilization of resources? By linking functional analysis to structural analysis of innovation system, it results in the identification of specific systemic problems as elaborated in the end of previous chapter. These findings indicate the urgent need to design an integrated systemic policy framework to address the problems in a more orchestrated manner. This chapter will propose a set of structure-related recommendation by first exploring the goal of systemic instruments to address the problems. It will be followed with some reflections gathered from the execution of this research, including evaluation of the application of framework for analyzing the case.

5. 1. General findings and corresponding recommendations

Policy makers generally have a quite restricted policy domain and therefore need to decide which system functions to influence directly which functions to influence through other actors. To come to this decision, they need to understand how well the system currently work and what possibly be the main problems (Bergek et al., 2008). Similarly, Wiezcorek and Hekkert (2012) proposed that identification of systemic problems is a prerequisite to choose approaches and tools to target the problem, thus enhancing the overall functions of the system. Those approaches and tools are called 'instruments' (Smiths and Kuhlman, 2004 quoted by Wiezcorek and Hekkert).There are eight types of systemic problems based on the structural – functional analysis. In order to be able to address all eight types of systemic problems, systemic instruments should focus on the corresponding goals as explained on below table. In this table, it is assumed that for the system function being analyzed, problems occur in all four structures.

Table 5-1 Linkage between system functions, problems, and goals of systemic instruments

System function	Structural element	Systemic problem	(Type of) Systemic problem	Goals of systemic instruments
Example: entrepre-neurial activities	Actors	Actors problem	Presence of actors	Stimulate and organize the participation of various actors (NGOs, companies, government etc.)
			Capabilities of actors	Create space for actors' capability development (e.g. through learning and experimenting)
	Institution	Institution problem	Presence of institution	Stimulate the occurrence of interaction among heterogeneous actors (e.g. by managing interfaces and building a consensus)
			Capacity/quality of institution	Prevent ties that are either too strong or too weak

System function	Structural element	Systemic problem	(Type of) Systemic problem	Goals of systemic instruments
	Interaction	Interaction problem	Presence of interaction	Secure the presence of (hard and soft) institutions
			Intensity/quality of interaction	Prevent institutions being too weak or too stringent
	Infrastructure	Infrastructure problem	Presence	Stimulate the physical, financial and knowledge infrastructure
			Capacity/quality	Ensure that the quality of the infrastructure is adequate (strategic intelligence serving as a good example of specific knowledge infrastructure)

While the coupled structural – functional analysis are *descriptive* and provide an analytical tool, systemic instruments are *prescriptive* and aimed at assist policy design and selection of tools that can address the problems in an integrated manner. The goal of systemic instruments describes what the instruments should do to create the circumstances to improve functioning of the system. Therefore, Wiezcorek and Hekkert (2012) proposed a number of individual instruments that can compose a policy mix to address the corresponding systemic problems in an orchestrated manner. Selection of instruments will be in line with systemic problems; but also considering the instruments' mutual interaction and the contextual social, political and economic circumstances. Therefore, these instruments can be applied effectively and in coordination with one another. The connection between systemic problems and systemic goals allows for a complete systemic policy framework.

In conclusion, findings of the research can be linked with the above framework, to draw some recommendations that will be categorized according to the relevant structure. The recommendations are as follows:

1. Actors-related recommendations
   - Intensify cooperation with parties with similar concern to renewable energy and energy access, such as through country bilateral cooperation or international forums.
   - Increase the frequency of business matching activities.
   - Reduce perceived risk by bank to finance renewable energy projects, such as through Viability Gap Fund scheme.
2. Institution-related recommendations
   - Revise Sumba Iconic Island Blueprint and Roadmap to reflect the new accelerated target and clarify how the target should be met by all stakeholders, including identification of responsible party for each activity. This official document will also serve as a point of reference for program monitoring and evaluation.
   - Speed up the issuance of feed-in-tariff that offers attractive return for wind power investment.

- Ensure institutional harmony between related regulations cross-ministries and cross level of governance (national and local).
- Provide an attractive incentive scheme that will reduce uncertainty of new investments and at the same time ensure that the schemes already in place are easily accessed by deserving companies.
- Provide continuous workshops to build the capacity of beneficiaries, civil society organizations, community partners, and government.
- Through the existing vocational school, develop classes or programs in renewable energy to ensure the continuation of capacity building in longer term and address human resources shortage.
- Design information and education campaign for raising awareness both of local residents and outside public.

3. Interaction-related recommendations
   - Enhance the existing connectivity between actors. Explore potential collaborations with universities and research centers, such as through cooperative research programs.
4. Infrastructure-related recommendations
   - Increasing the quality of physical infrastructure in Sumba Island to support renewable energy installations and overall project implementation.

5. 2. Reflections from this research

Renewable energy in Indonesia is a newly explored technology, and the application of this technology in Sumba is brought about by multi-stakeholder approach. Implementation of Sumba Iconic Island is therefore highly dynamic and connects many parties in and outside the country. Coupled structural-functional analysis framework is considered suitable to capture the dynamics of events and activities that occur in the process of implementing the concept of Iconic Island. The functionality evaluation can deliver the identification of specific blocking mechanism that hinder the target achievement, and policy instruments are readily definable once the analysis is complete.

The time and resources allocated for this research did not allow for an analysis of the complete list of system functions as proposed by innovation scholars. Assessing other system functions, such as the one exploring government's and state-owned utility company's actual expectation and target on developing renewable energy ('Guidance of the search' in Hekkert's list or 'Influence in the direction of search' of Bergek's list) will be important in adding value to the analysis.

For future studies based on this research, more number of in-depth interviews would be necessary to acquire a more thorough system assessment. The distance between the researcher and interviewees posed problems in the ease of reaching interviewees, for example the limited internet connection in parts of Sumba Island to conduct Skype interview. At times it influenced the consistencies in which the questions were asked.

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Appendix 1 List of interviews and consultation with key stakeholders

No	Institution	Function	Interview method	Date of interview
1	Hivos	Two representatives were interviewed and consulted for this research: • Program Manager • Stakeholder Engagement Officer	Skype	August 1, 2016
2	Jasa Kasih Cooperative in Kamanggih Village	Chief of Cooperative	Skype	August 9, 2016
3	Sumba Tengah District Energy and Mining Agency	Head of Agency	Email	September 5, 2016
4	Ministry of Energy and Mineral Resources, Directorate General of New Renewable Energy and Energy Conservation	Section Head of Various Renewable Energy Cooperation (As person in charge for Sumba Iconic Island)	Email	September 7, 2016
5	PT. Sumberdaya Sewatama	Now: Chief Growth and Operation Renewable Energy At the time of the project: Business Development Manager	Skype	September 9, 2016
6	Sumba Barat Daya District Mining and Energy Agency	Section Head of Electricity, Oil, Ground Water and Subsurface Water	Skype	September 14, 2016
7	Nusa Tenggara Timur Provincial Mining and Energy Agency	Section Head of Electricity Energy Conservation, Electricity and Energy Utilization	Email	September 25, 2016

Appendix 2 Interview Guide

<u>Function Entrepreneurial activities:</u>

1. How many actors contributing to enterpreneurial activities?
2. To what extent entrepreneurs were involved in the SII?
3. What are the existing incentives/facilities from the government for doing investment?
4. Is the availability of incentive considered enough?
5. Is there any guideline for entrepreneurs that are interested to join the project?
6. Does the entrepreneur face challenge in obtaining business permit or license?
7. What are the efforts to increase the level of investment of renewable energy?

<u>Function Knowledge development and diffusion</u>

8. Are there any collaboration between your organisation and universities?
9. How is information disseminated for the beneficiaries?
10. How is the interest of beneficiaries to learn about renewable energy?
11. Is there any change in behavior due to the program?
12. Are there enough capacity building activities for beneficiaries for the purpose of project maintenance?
13. Is there opportunity for knowledge dissemination outside the project area? (e.g. workshop, conferences, expedition activities)
14. What are the topics of the workshop?

<u>Function Resources mobilization</u>

15. What are the financial resources mainly used for (e.g. research, application, pilot projects)?
16. Is there adequate public funding or private funding?
17. How is the availability of human resources in the island?
18. How is the availability and sufficiency of physical infrastructure?
19. Is there any physical challenge of project implementation?
20. How has been the interaction between Hivos and your organization?