The tangled thread:
Fragmentation of biogas governance in Indonesia

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Summary

Since the past decades, the Indonesian economy has recorded rapid growth that led to heavy dependence on fossil fuel for energy generation and rapidly rising carbon emissions. In term of energy for cooking, the dominant sources in Indonesia are LPG (liquefied petroleum gas) and firewood. About 40 percent of households still use firewood as a cooking fuel, which contributes to forest degradation, climate change, and health issues such as breathing disorders. Meanwhile, LPG is one of the sources of greenhouse gas emissions in the country. Alternatively, biogas is considered a cleaner source that can be introduced to tackle those problems, especially in small-medium scale such as the household level. However, there is fragmentation within small-medium scale biogas programs in Indonesia that led to conflict among the programs. The problem of fragmented governance, with weak institutions, makes policies are vulnerable to ineffectiveness that hinders transition pathways for low carbon development through biogas sector. Until 2015, the total number of biogas digesters only accounts for 1.24 percent of households and biogas is hence much less common than other cooking fuels. There are some dissemination barriers constraining fuel substitution with biogas, from the bureaucratic process, the time-consuming process of feedstock, social acceptance, different priority, monitoring practices, and poor technological maintenance. These multiple barriers to dissemination are exacerbated by the problem of lacking coordination in the fragmented governance of the biogas programs. This research aims to explore the landscape of biogas governance in Indonesia, its fragmentation, and its effectiveness for policy delivery.

The conceptual framework of this research combines theories of fragmentation and polycentric governance as a framework that features specific aspects within biogas regime. This research utilizes both theories to link the indicators within it, which are the power distribution and cooperation dynamics. For methodology, this research utilized qualitative data analysis. This method involved multiple forms of qualitative data that consist of interviews, document reviews, and series of analysis in relation to the conceptual framework. Twenty-two semi-structured interviews were conducted during the field work and it utilized purposive and snowball sampling technique. The focus is on four institutions which have biogas programs, such by Hivos (NGO), Ministry of energy, Ministry of Agriculture, and Ministry of Environment. Sources from representatives of various stakeholders were chosen in those different institutions, to balance the information.

The result of this research found that biogas programs are scattered in different ministries (also scattered in different directorates or sub-institution within the ministry), such as the Ministry of Agriculture (MA), the Ministry of Energy and Mineral Resources (MEMR), and the Ministry of Environment and Forestry (MEF); and in Hivos. The ministries have a wide range of problem background to justify their biogas programs, which are related to policies of the energy mix, climate change mitigation, food security, and forest conservation. Yet, almost all those governmental biogas programs relatively have the same characteristics; using the grant approach, cooperate with local government and vendor, and do not have proper training and monitoring-evaluation scheme. There is no effective coordination among these government programs that result in a lack of cooperation to achieve the bigger target for renewable energy dissemination and emission reduction. Meanwhile, the Hivos' program called BIRU utilizes semi-commercial approach; collaborates with multiple stakeholders such as government bodies, construction partner organizations, cooperatives, and private sectors (companies and banks); and has standardized training and after sale services. The fragmentation triggers innovation in different biogas programs.

From 2007 to 2017, there has been the dynamics in cooperation and power distribution within biogas governance architecture in Indonesia, that trigger periodical shifts of configuration within the regime, from administrative fragmentation in 2007-2009, conflictive fragmentation in 2010-2013, cooperative fragmentation in 2014-2016, and reduced fragmentation in 2017. In 2007-2009, there were

only biogas programs from different ministries, without the intervention from Hivos. From 2010 to 2013, Hivos established BIRU that had installed about 11K digesters. At the same time, the MEMR also disseminated 4K digester. BIRU derived more donors and the MEMR gained more budget allocation for biogas programs, it caused more money being available for their collective biogas dissemination. BIRU's strategy to train CPOs also created more expertise on biogas builders. This contribution increased the total number of biodigester dissemination to be 16 K units. The establishment of BIRU and the emergence of Directorate of Renewable Energy in the MEMR increased the degree of fragmentation to biogas programs. This power distribution triggered speed of program implementation that resulted in the rise of the number of dissemination. Yet, the absence of coordination within the distributed power triggers conflicted fragmentation. This situation happened in the biogas governance architecture in 2010-2013. Coordination and cooperation are required to harmonize the distributed power within the architecture. The cooperation started to develop in 2014.

In 2014-2016, coordination of BIRU with more government bodies had effects on output of biogas programs. This cooperative fragmentation increased the number of biodigester dissemination more than doubled in three years, from 16K in 2013, to 37K in 2016. The cooperation also affected the training of users in biogas programs. There is more standardized training implemented in biogas programs. The standards were made by Hivos and YRE through BIRU program that trained many construction partner organization (CPOs) to train biogas users. These CPOs also applied the same standards when they worked with other biogas programs from the ministries and local governments. In 2017, a new centralization policy from the government reduced the power distribution within the biogas governance architecture. This change contributed to the decline in the number of biodigester dissemination. At the same time, the centralization also stopped the transformation of biogas governance architecture to move forward to the polycentric governance model.

The degree of fragmentation in biogas programs in Indonesia has affected the number of biodigester dissemination and its knowledge transfer among the stakeholders. The main conclusion of this research is that the cooperation between NGO, the governments, and other institutions contributed to the increasing number of biodigester dissemination. Cooperative fragmentation increased the number of biodigester dissemination and its knowledge transfer.

Nature of the biogas sector is fragmented, and it requires multi sectors collaboration from energy, agriculture, environment, and village development. Beyond cooperative fragmentation, polycentric governance can be utilized to tackle cross-sectoral dissemination barriers of biodigester, such as the availability of manures that depends on cattle supply from the MA. The cross-sectoral collaboration can bring better output, outcome, and the environmental impact of biogas programs. To achieve it and as implications of abovementioned findings, two types of recommendations are provided; 1. Practical policy recommendation to increase the performance of biogas policy and governance, and 2. Further research to strengthen the implementation of the policy recommendation, and to explore the innovation in the field of environmental-energy policy and governance (See Chapter 7).

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1 EUR:	17,486.92 IDR (Indonesian Rupiah)
BIRU:	Domestic biogas program
CPOs:	Construction Partner Organizations
CTF	Climate Task Force
GoI:	The government of Indonesia
Hivos	International Humanist Institute for Cooperation with Developing Countries
KPSBU:	Cattle Farmers Cooperative in North Bandung
LPO	Loan Partner Organization
M&E	Monitoring and Evaluation
MA:	Ministry of Agriculture
MDP	Ministry of Development Planning
ME:	Ministry of Economy
MEF:	Ministry of Environment and Forestry
MEMR:	Ministry of Energy and Mineral Resources
MF:	Ministry of Finance
MHD:	Ministry of Human Development
MM	Ministry of Maritimes
NEC:	National Energy Council
NEP:	The National Energy Plan
NGO:	Non-Governmental Organization
RE:	Renewable energy
RERC	Renewable Energy Research Center
SAF:	Special Allocation Fund or DAK

YRE: Home of energy foundation (recheck the translation), a national NGO

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Chapter 1: Introduction

Indonesia is one of the world's biggest greenhouse gas emitters (Austin et al., 2018; Sunstein, 2007). Over the past decades, the Indonesian economy has recorded rapid growth that led to heavy dependence on fossil fuel for energy generation and rapidly rising carbon emissions. In term of energy for cooking, the World Bank (2013) and (BPS, 2016) found that about 24.8 million households or 21-40% of all Indonesian households use traditional biomass (firewood) as their primary cooking fuel (BPS, 2016). This activity contributes to forest degradation and climate change and also accounts for high levels of breathing disorders (Abdullah, 2002). Another dominant source of energy for cooking in Indonesia is LPG. Since the conversion program from kerosene to LPG in 2007, the demand for LPG has increased significantly. Indonesia relies on imports to cope with a shortage of the LPG. Indonesia remains a net importer of petroleum products such as liquefied petroleum gas (LPG) due to the lack of refining capacity and the inability to meet rising demand with domestic production. In addition, analysis of the LPG program found that the program does not significantly lower the average number of energy-poor people in rural areas (Andadari, Mulder, & Rietveld, 2014). Both firewood and LPG are sources of environmental degradation in the country. To solve that problem, biogas is considered a simple and relatively affordable technology that can be introduced.

Biogas offers a cleaner energy source for cooking and electricity. Biogas is one of the second-generation biomass energy forms in bioenergy technologies generated from agricultural waste such as livestock manure as feedstock input. Those feedstocks are mainly located in rural areas of Indonesia (TRANSrisk, 2017). The use of biogas digester or biodigester for cooking has the potential to reduce the dependence on LPG and firewood. Biogas digesters can be used for thermal processes to generate electricity for equipment, such as rice driers, fish or cocoa driers and boilers, or as an energy source for other machine tools such as the cooking stove (Haryati, 2006). There are multiple co-benefits of biogas; reducing emission, saving time for farmers, avoid indoor pollution from firewood use, reduce the reliance on LPG, and producing bioslurry for fertilizer and additional income (See Appendix 4).

The government of Indonesia (GoI) established two policies that are related to biogas dissemination. First, the energy mix policy is targeting to reach 23% of renewable energy (RE) by 2025 and 10% of it is expected from bioenergy (Kumar, 2016). Second, biogas is mentioned as one of the programs in the RAN-GRK or National Action Plan for Reducing Greenhouse Gas Emissions (Bappenas, 2010). In 2009, the GoI established the RAN-GRK as its mitigation plan to contribute towards the achievement of the country's carbon emissions reduction target. Biogas has potential to contribute to integrating climate change mitigation and adaptation in agriculture. In mitigation, biogas utilizes agricultural by-products and waste to increase clean energy services to rural households (Ardiansyah, et.al, 2012). For adaptation, biogas supports people to generate agriculture-based income (Ardiansyah, et.al, 2012). Some local farmers in several provinces utilize biogas to empower their small business (Su-re.co, 2017). This activity belongs to climate change adaptation as it diversifies rural livelihood (Budiman, Takama, Pratiwi, & Soeprastowo, 2016). However, in the National Adaptation Program of Action or RAN API, there is no specific action plan about the biogas development. The progress of biogas for climate change adaptation is still slow. Under the sub-sector of energy security for economic resilience, the RAN API only mentioned plans to develop high productivity and climate stress resistance crops for bioenergy or biomass and biofuels (Bappenas, 2013).

1.1 **Problem description**

The biogas programs in Indonesia are developed at various scales, which are small-and medium-scale (households and farmers group), industries, and large-scale power generation (Ardiansyah, Gunningham, & Drahos, 2012). The use of biogas for small-medium scale is less

concerned in Indonesian energy and climate policy. There is no clear target for dissemination for small-medium scale biogas. Both energy and climate policies in Indonesia indicate that biogas development is expected to generate clean energy for electricity. These policies pay more attention to the biogas for large-scale electricity (Hasan, Mahlia, & Nur, 2012). This research focuses attention on the biogas programs for farmers group and households' scale.

Until 2015, the total number of biogas digesters only accounts for 1.24 percent of Indonesian households and biogas is hence much less common than other cooking fuels (BPS, 2016). According to Transrisk (2017), there are some dissemination barriers and factors constraining and enabling fuel substitution with biogas, as follows;

- The lengthy and bureaucratic process to apply for support from biogas programs
- The time-consuming process of feedstock/waste collection
- Cultural food preferences associated with traditional cooking methods
- More attention is given to other aspects (agriculture and environment) of biogas, such as animal waste management and collective (waste) management issues in the case of larger biogas systems
- Varied (and lack of) monitoring practices in different programs
- Poor maintenance (TRANSrisk, 2017)

These multiple barriers to biodigester dissemination are exacerbated by the problem of the fragmented governance structure of the biogas programs. This problem is related to the absence of coordination and integration among biogas programs that limits cooperation among them.

Small-medium scale biogas programs in Indonesia are scattered and fragmented in different institutions. This fragmentation leads to conflict among the programs. The strategies in Indonesia's bioenergy policy are not unified and there is no support from strong institutions (R. Singh & Setiawan, 2013). This incoherence is caused by the exclusiveness of particular institutional actors, which leads to the ineffectiveness of the programs' output. This fragmentation is a problem, not only for the sake of national policy coordination and its evaluation but also for international policy. The fragmentation causes double counting for greenhouse gasses emission reduction (Ochieng, Visseren-Hamakers, Arts, Brockhaus, & Herold, 2016).

Environmental governance architecture in Indonesia is often fragmented, with weak institutions (Suramenggala, Subarudi, Obidzinski, & Smith, 2012). It makes environmental policies are vulnerable to ineffectiveness that hinders transition pathways for low carbon development. Lack of coordination becomes a problem within fragmented governance (Bapna, Barua, Mani, & Mehra, 2010). The concept of fragmentation analyzed linkages across the policy domain and a relationship between the different institutions which were filling regulatory void. Existence and interaction of different institutions on the architecture of the overall institutional setting is the focus of the fragmentation concept of governance (Biermann, Pattberg, Van Asselt, & Zelli, 2009). Domains of environmental governance—like climate change and renewable energy—are already fragmented. The debate is whether a fragmented governance architecture is more effective for policy delivery (Zelli & Van Asselt, 2013). Despite the opportunities for boosting climate action, the effectiveness of that governance architecture is still being questioned (A. J. Jordan et al., 2015).

In biogas case in Indonesia, the fragmentation comes from scattered biogas programs from several ministries, local government initiatives, local NGOs, and companies. The Indonesian government has a number of voluntary biogas programs from the Ministry of Energy and Mineral Resources (MEMR), the Ministry of Environment and Forestry (MEF) and the Ministry of Agriculture or MA (TRANSrisk, 2017). The MEMR provides the biogas program as part of their renewable energy program. The MEF promotes the biogas program for the community surrounding the forest to prevent them using the firewood from the forest (TRANSrisk, 2017). The MA has a biogas program that is

combined with their integrated farming program as the practice of climate-smart agriculture (PSP, 2015). Biogas digesters under government-led programs were provided with the full subsidy (TRANSrisk, 2017). To date, there are no reliable numbers about the number of dissemination of biogas digesters in those governmental biogas programs (Transrisk, 2017).

From NGO, there has been BIRU (Domestic Biogas) program since 2009. This program was established by Hivos and SNV, in partnership with the MEMR. Later, BIRU also has started to work together with some other biogas programs. Different with the government, BIRU program has started dissemination of biogas with a market-based approach. BIRU is supported by international financing power, and knowledge resources from professional actors (TRANSrisk, 2017).

Biogas policy and governance architecture in Indonesia seem not integrated into a single framework. Fragmented governance architecture makes biogas programs come with different approaches and several types of digesters. Despite the existence of those different biogas programs, the total number of biogas digesters is still much smaller, compared to other cooking fuels (BPS, 2016). Yet, BIRU development from 2009 seems to affect the degree of fragmentation and it may affect the (in)effectiveness in the biogas programs for the household.

1.2 Research questions

Following from the problem statement, the objective of this research is to understand the degree of fragmentation of national biogas programs and how does it influence the output effectiveness of the biogas policy. Policy output is defined as the number of biogas digesters dissemination and transfer of knowledge in biogas programs. In pursuit of this objective, hence the following main question is then asked:

How did the fragmentation of biogas programs in Indonesia affect the dissemination of biodigester and the knowledge transfer, between 2007 to 2017?

The main research question is developed from three sub-research questions:

1) What are the governance arrangements, characteristics, and dissemination barrier of biogas programs in Indonesia?
2) How is the coordination and distribution of power within fragmented biogas architecture?
3) How does the coordination and power distribution within the architecture affect the dissemination of biodigester and the knowledge transfer?

This study focuses on the development of biogas programs from 2007 to 2017 in order to cover the dynamics from biogas program in the MA in 2007, the emergence of BIRU in 2009, and a shift in biogas program partnership from 2012 to 2017. This period is chosen also because of the adjustment with the availability of data from different institutions.

Three sub-questions aim to construct an analysis to answer the main research question. The first sub-question explains about general characteristics of each biogas program that consists of the description of programs, key changes, partners for cooperation, and reflection within the program. This sub-question also describes governance arrangement in each program. Each governance arrangement has their own characteristics that influence their mutual coordination. It relates to the second sub-question that shows the aspects of fragmentation in the biogas regime, its historical shift, and the institutional complexity in biogas governance architecture. The last sub-question looks at the regime effectiveness of the fragmented biogas architecture. It identifies interaction among the biogas programs and how it shapes the policy output, indicated by the dissemination of biogas digester and the knowledge transfer about biogas. Policy output from fragmented biogas programs is measured from

those two indicators (see Table 3). The causality is analyzed in the process of collective action or cooperation by different biogas programs.

From those questions, this research contributes to academic discourse in environmental-energy policy and governance, especially in order to improve the performance of bioenergy policy planning and governance practices. Biogas case in Indonesia is a suitable topic to study theoretical debate of fragmentation in environmental policy and governance because the country has emerging development in governance architectures that has dynamics on coordination and distribution of power among institutions. It provides theoretical insights that configuration shift in different types of fragmentation, within the regime; offers the contribution to the development of environmental policy and governance. Practically, this study also provides lessons of coordination and cooperation network for existing biogas programs and projects and its stakeholders.

1.3 Outline of the report

After this chapter, this report is continued by six more chapters about conceptual framework, methods, results, discussion, and conclusion-recommendation. Following Chapter 2 describes the theoretical and conceptual framework that explains about theories of governance arrangement, fragmentation, and polycentric governance; and the implication of theories for the research in form of the conceptual framework. Chapter 3 depicts the methodology of this research. Chapter 4 utilizes the framework to analyze the empirical result that analyzes biogas policy, its implementation in various programs, and its dissemination barrier. In Chapter 5, governance architectures of the fragmented biogas regimes are built and analyzed to show its implication to policy delivery, to show the effect of fragmentation on the output effectiveness of biogas policy in Indonesia.

In Chapter 6, this paper discussed the strength of the findings of this research. It connects to the notion of polycentric governance that influences the degree of fragmentation in environmental-energy governance. This chapter also reflects on other issues on the methodology and the theoretical framework. In addition, this chapter recognized the limitations of this research as well. Chapter 7 answers the research questions through conclusion and provide the further recommendation for biogas governance and future potential research to enrich the theoretical frameworks.

Chapter 2: The theoretical and conceptual framework

This chapter introduces the theories used in this research and its merge into a conceptual framework that is operationalized to answer the research questions. Table 1 shows the linkage between the theories and the research questions. The concept of policy effectiveness by Crabbé & Leroy (2012), fragmentation by Bierman (2009), and polycentric governance by Ostrom (2001) and Pahl-Wostl, & Knieper (2014) are three theories explained in this chapter. In 2.1 and 2.2, a description of those theories and their developments through critical notes are described. In 2.3, the use of these theories in this research is explained in the conceptual framework.

Table 1 Topics and theories the research questions

Sub-research question	Themes	Theories
1	Characteristics of program/policy	Governance arrangement
2	The historical shift of regime complex configuration	Fragmentation & Polycentric governance
3	Influence on policy output performance	Policy effectiveness

2.1 Governance arrangement

The term biogas governance is used in this research. The word of governance implies that the sector is not the exclusive responsibility of public sector institutions but involves relationships between government and non-governmental actors. Rakodi (2003) argued that the key tasks for government in this context are coordinating an increasingly complex and fragmented governance architecture, and integrating diverse networks. Inter-dependent activities must be steered through new institutional frameworks, to support bargaining processes for conflict resolution (Rakodi, 2003). The question when considering these issues is under what conditions do different governance strategies and arrangements for each biogas program work effectively in collaboration and for which purposes.

Governance could be a process to solve the dilemmas of collective action (Driessen, Dieperink, van Laerhoven, Runhaar, & Vermeulen, 2012). Choices between the voluntary and economic instrument are a dilemma for collective action in biogas programs. The stakeholders need to determine the effective strategy to govern the biogas regime. Operationalization of governance arrangements in each program should be analyzed collectively from the frame of regime architecture, to result in effective output and outcome (Arnouts, van der Zouwen, & Arts, 2012).

Driessen (et al 2012) outlines five types of governance arrangement; centralized, decentralized, public-private, interactive and self-governance. The categorization is based on interactions and relationship between different actors, such as state, market or businesses, and civil society like NGO (Driessen et al., 2012). This relationship implies the coordination between the institutions inside a governance arrangement. Decentralized type involves the coordination between national government and local government. While interactive governance provides mutual interaction between government, businesses, and NGO (Driessen et al., 2012). The elements of coordination in governance arrangement affect choices of programs approach, partners for cooperation, and capacity to tackle the implementation barrier (Biggs & Smith, 2003). These points are used in this research as aspects to describe general characteristics of each biogas program, to answer the first sub-research question.

2.2 Configuration of regime complex: Fragmentation and polycentric

Each biogas program has their own governance arrangement. Combination of different governance arrangements forms a regime complex or a bigger governance architecture of biogas policy. The second sub-research question in this research aims to understand changes in regime configuration during the

period of 2007 to 2017. To figure it out, the concept of fragmentation and polycentric governance are seen as the configuration of the biogas regime. Both theories of fragmentation and polycentric governance are utilized to analyze dynamics in biogas governance architecture in Indonesia.

2.2.1 (Conflictive) fragmentation

The idea of fragmentation began from the debates about interlocking institutions (Cullet, 1999). It analyzed linkages across the policy domain and a relationship between the different institutions which were filling regulatory void. Existence and interaction of different institutions on the governance architecture of the overall institutional setting is the focus of the fragmentation concept. The architectures of governance are almost never fully interconnected and integrated, it is fragmented (Biermann et al., 2009). The concept of governance architecture can be used for comparative analysis of issues and policy. In the global climate governance architecture, there has been fragmentation due to lack of the overarching level for interlinkages between institutions (Zelli, 2011). Bierman (et.al. 2009) found that some stakeholders agree that the architecture of climate governance must affirm the value of fragmentation as "diversity".

The fragmentation theory is usually applied to transnational governance. Keohane and Victor (2011) saw the fragmentation as the formation of a regime complex which is generated by the structural and interest diversity inherent in contemporary politics. In national level, Smits (2017) argued that the competition between different national entities results in fragmentation that reflects the persistence of domestic power relations (Smits, 2017). This study argued that the degree of fragmentation actually varies from international to the national case. In Indonesia, one of the cases of fragmentation happens in the implementation of national biogas programs. This research is applying the fragmentation concept for national-based governance of biogas in Indonesia. It is expected to bring theoretical innovation by examining the operation of the regime complex in national policies that do not only involve the state actors but also non-state actors such as NGOs and private sectors.

In the context of climate policy, biogas is considered an action that synergizes mitigation with adaptation (P. Smith & Olesen, 2010). It makes biogas programs can come from different government institutions related to environmental and climate action such as agriculture, energy, and forestry. This phenomenon is seen as administrative fragmentation where different government bodies have the same type of policy or programs which is not integrated (Carter, 2001). In biogas governance in Indonesia, this administrative fragmentation is more complicated due to the existence of important role from non-state actors in the biogas program.

Biermann et al. (2009) categorize three types of fragmentation; conflictive, cooperative and synergistic. This research focuses on conflictive and cooperative fragmentation because it is relevant to the case of fragmented biogas programs from 2007 to 2017. Conflictive fragmentation reflects a situation in which there are conflicting principles and rules among the institutions or programs due to lack of coordination. In conflictive fragmentation, there are different programs coming from different policies, with unclear governance architecture. This regime lacks coordination, so its distribution of power has overlapping responsibilities and different decision makings that cause contradicting actions with low output effectiveness (Pahl-Wostl & Knieper, 2014). These conflicts hamper priorities to reach substantive goals and primary objectives of the climate action. In addition, it decreases the opportunity for partnerships to be fostered (Gupta, Pistorius, & Vijge, 2016).

The fragmentation theory helps the second sub-research question of this study to understand the problem of conflict in biogas programs. Conflicting principles and rules, coordination, distribution of power and responsibilities, and partnerships are analyzed among the institutions or biogas programs (See section 2.3).

Another type of fragmentation is cooperative fragmentation where institutional architecture between state and non-state actors is loosely integrated. The following section elaborates more on cooperative fragmentation and its relationship with polycentric governance.

2.2.2 Polycentric governance and cooperative fragmentation

Polycentric governance is originated from the concept of polycentric systems for implementing policy and governing particular problem in an area. The polycentric system is a multi-level governance that involves various actors as the center for the governance (Marshall, 2008). The system allows multiple actors such as civil society and private sectors to lead the governance architecture (Ostrom, 2010). The emergence of a national program that led by non-state actors is an example of polycentric governance (Biesbroek, 2018). The polycentric regime has centers from the organization of different scales of democratic units that each may be independent to create and enforce rules for a specific area, within a limited scope of authority. Some units may be self-organized as NGO or parts of local governments system (Ostrom, 2001).

Pahl-Wostl, & Knieper (2014) argued that polycentric governance is in the same dimension with cooperative fragmentation because both have the wide-range distribution of power that fosters a policy to include more people or stakeholders inclusively. Those stakeholders perform effective coordination and cooperation across various levels. Coordination is feasible in the cooperative fragmentation regime that has loosely integrated institutional architectures. Cooperative fragmentation links to two criteria, which are coherence and inclusiveness. First, coherence is where the programs within the regime are compatible and mutually reinforcing. The coherence is answering the challenge of lack of coordination in conflictive fragmentation and resulting effective cooperation between the actors. Second, inclusiveness leads to institutional fit among the actors (Widerberg & Pattberg, 2015). Inclusiveness can be used as a criterion to assess the added value of the regime. Inclusiveness provides open access to information that can increase the legitimacy of the regime and its programs (Widerberg & Pattberg, 2015).

Cooperative fragmentation also links to two key advantages which are flexibility and adaptability (Keohane & Victor, 2011). It makes the actors have more space to choose the appropriate action, depending on what fits their capabilities. Biermann (et al. 2009) found that the fragmentation may accelerate the speed of programs' implementation. Small governance architectures are easier to be applied to the target group. It is circumventing negotiation stalemates in the governments. Specific institutional architectures can better account for a specific/contextual situation of preventing the problem (Biermann et al., 2009).

Meanwhile, polycentric governance combines scales (such as local/national), mechanisms or program approach (such as subsidies and credits), and actors (such as government, business stakeholders, and civil society) – to support equity, inclusivity, knowledge transfer, accountability, organizational multiplicity, and adaptability. Organizational multiplicity is the condition in which multiple actors are involved to deepen program coverage and offer parallel systems of governance. Those aspects can increase the effectiveness of climate and energy policy (Sovacool, 2011). The increase results from the partnership between actors and the resolution of problems among them (Sovacool, 2011).

Zelli & Van Asselt (2013) argued that the concepts of fragmentation and polycentricism are a diversity of initiatives or ‘the invisible hand’ of a market of institutions. The diversity is believed to bring a better distribution of functions and effects. The relation between fragmentation theory and polycentric governance is a key concept in this research. Based on above explanations, Table 2 summarizes previous explanations and compares both theories based on the following questions; where

do the theories come from; what are the assumptions; to what extent are they normative; and what are their typical examples/cases.

Table 2 Relation between fragmentation and polycentric governance

	(conflictive) fragmentation	(cooperative) polycentric governance
Origin of theories	Debates about interlocking institutions	Polycentric systems for governing problem
Assumptions	Architectures of governance are almost never fully interconnected and integrated	A wide-range distribution of power fosters a policy to include more people or stakeholders inclusively, performing effective coordination
Normative degree	Some stakeholders agree that the architecture of governance must affirm the value of fragmentation as "diversity"	The diversity of initiatives is the invisible hand of a market of institutions that bring the better distribution of functions and effects.
Typical examples	Transnational governance	Civil society and/or private sectors lead the governance architecture
Criteria/indicators	In/(ex)clusiveness and (in)coherence	Distribution of power and effective coordination

The second sub-research question utilizes both theories of fragmentation and polycentric governance, to look at historical shifts of configuration in biogas regime, from conflictive to cooperative fragmentation. This research is finding out whether there is the opportunity for cooperative fragmentation and polycentric governance to be an enabling factor to overcome biogas dissemination barrier.

2.3 Output effectiveness

To measure the effectiveness of the output of each biogas program and the collective output of the biogas regime, policy effectiveness theory is utilized in this research. In this theory, there is a distinction between the effects of (environmental) policy, which are to output, outcome, environmental impact, and social needs. These classifications are used to evaluate the effectiveness of environmental policy (Crabb & Leroy, 2012).

In the wider context, policy effectiveness links to the topic of policy evaluation. In the light of policy effectiveness contexts, this discussion relates to narration about the policy change. Hall (1993), established a taxonomy of policy change into three steps. The second-order change involves a change of policy instrument (e.g. replacing voluntary with a market-based approach) (Hall, 1993). Moreover, an evaluation of the effectiveness of regime complex may lead to policy change among the institutions.

In this research, that theory is utilized to measure the output effectiveness of biogas programs and its governance architecture. The focus is on the effects of fragmented biogas regime on the performance of output in biogas programs. Policy output consists of several aspects that include the quantity and quality of the products and/or services delivered by policy and its governance arrangement or architecture (Crabb & Leroy, 2012). These aspects are used as indicators to answer the last sub-research question in this study. More explanation is on the following section.

2.4 Conceptual framework

This section explains the strategy to develop the step from a theoretical framework to the method by operationalizing the theories above into a conceptual framework and the topic list to guide data collection. This conceptual framework combines above-mentioned theories as a framework that

features specific component/aspects in fragmentation and polycentric governance. Fragmentation theory is commonly used for global environmental policy and polycentric governance is more for national/local policy. In this section, the context of both theories is adapted to the case of biogas programs in Indonesia. This research utilizes both theories to link the indicators within it.

2.4.1 Coordination and distribution of power

Figure 1 shows how two aspects of both main theories are connected; inclusiveness in fragmentation regime determines the distribution of power in polycentric governance, and coherence is built from effective coordination. Distribution of power is a core concept of decentralization that divides the power in the form of separated function between different institutions such national, local government, and non-state actors. Within biogas governance architecture in Indonesia, there have been different regime configurations happening among the programs. Conflictive fragmentation and polycentric governance are two types of possible configuration.

In Figure 1, there are three quadrants that show the regime configuration. The horizontal axis depicts the distribution level of power, from centralized to inclusively distributed. The vertical axis shows the degree of cooperation in the programs, from lack of coordination to coherently connected. In polycentric governance quadrant, there is a well-distributed power among institutions, with effective cooperation among them and their programs. Meanwhile, conflictive fragmentation quadrant has a bit lower distributed power among institutions, as well as lack of coordination among them. Another quadrant is centralized governance where the power is centralized and coordinated by a single institution.

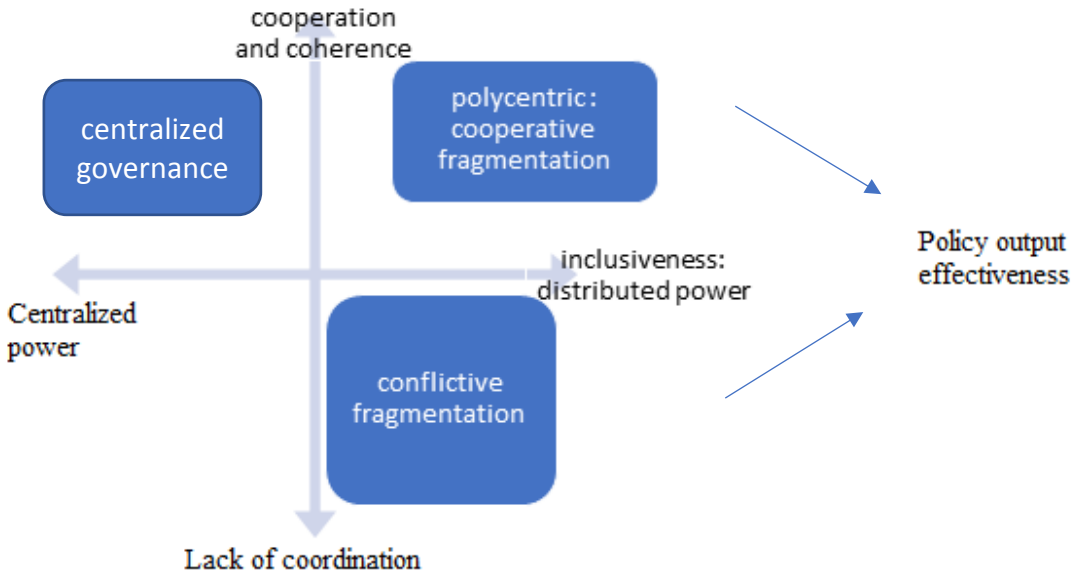

Figure 1 Conceptual framework (adapted from Pahl-Wostl & Knieper, 2014)

2.4.2 The Indicators

To operationalize the theories of fragmentation and polycentric governance, I modified the work from Pahl-Wostl, & Knieper (2014). Table 3 lists the indicators as the topic list to define the situation of 'distributed power' and 'cooperation' in the configuration of conflictive fragmentation and polycentric governance or cooperative fragmentation.

The power distribution aspect shows how the resources are allocated among actors, either centralized or decentralized. Three types of resources are used, which are the authority, finance, techno-scientific knowledge (TRANSrisk, 2017). These resources affect the development and implementation of biogas programs. This indicator also influences the level of partnership among programs. Distribution of power affects to what extent responsibilities are divided among them within governance architecture, and whether it is in line with personnel capability of each institution.

Coordination includes horizontal and vertical coordination. The existence of a coherent piece of the framework that integrates biogas policies is checked. Then, the measure of coordination is also examined through how far governance architectures of the biogas programs or regime can facilitate coordination and support collaboration between actors across administrative levels and sectors, such as involving cross-sectoral institutions and local governments. Since 1999, Indonesia has practiced rapid government decentralization (Green, 2005) and biogas programs have been adapting to that system.

Table 3 Indicators as the general topic list (adapted from (Pahl-Wostl & Knieper, 2014)

Aspects\regimes		Conflictive fragmentation	Cooperative fragmentation/Polycentric governance
Aspects and indicators	Inclusiveness: distributed power	There is no partnership in policy/program's planning and implementation	There is the partnership in policy/program's planning and implementation
		Across programs, no distribution of institutionalized functions, responsibilities, and power	There is the distribution of institutionalized functions, responsibilities, and power across programs
		Across programs, no task division in accordance with the available personnel capability	There is a task division among programs, in accordance with the available personnel capability
	Coordination and cooperation	There is no national biogas-related policy is coordinated/integrated into one single piece of the framework (i.e. national biogas plan)	There is a national biogas-related policy is coordinated/integrated into one single piece of the framework (i.e. national biogas plan)
		No Formal provisions to support coordination among organizations across administrative levels and sectors– cooperation and clear allocation of tasks and functions as coherence	There are (in)formal provisions to support coordination among organizations across administrative levels and sectors– cooperation and clear allocation of tasks and functions as coherence
		No significant involvement of local institutions in biogas programs or in the creation of biogas-related institutions	There is significant involvement of local institutions in biogas programs or in the creation of biogas-related institutions
Output effectiveness of the regimes			
Indicators; • The number of biogas digesters disseminated • The amount of information (training) provided			

This research figures out how the aspects of cooperation and distribution of power in the biogas regimes result in the different impact on the performance of policy output. This topic is connected to the topic about the effect of fragmentation toward output effectiveness in biogas programs. This topic is engaging with policy effectiveness theory. This theory is operationalized by using the indicators which are the number of biogas digesters disseminated, and the amount of information provided through training (Table 3). So, those indicators are applied to each biogas program and its accumulation from different biogas programs as a biogas regime. Yet, there may be a time delay to evaluate the collective output. So, this research also evaluated the mechanism/process of cooperation among programs (depicted as the arrow in Figure 1) within the regime to result in output effectiveness.

This analysis is connected with the dynamics in the fragmentation from 2007 to 2017. The causality between fragmentation and policy output is analyzed by looking at the dynamic process of power distribution and coordination-cooperation among actors, and how it influenced the increase or decrease of biodigester dissemination and quality of knowledge transfer about biogas, from biogas programs to the users.

Chapter 3: Methodology

This chapter explains the qualitative methods used in this research. Section 3.1 describes the method of data collection, including the list of information sources. Section 3.2 provides an overview of the integration of data collection and steps of data analysis in this research.

In this study, Indonesia is considered as the unit of analysis, with the focus on the case of national biogas programs for households and groups (such as farmers groups). The households utilize small-scale biodigester-with the size of 4-6 m^3, and the groups utilize medium-scale biodigester, sized about 20-40 m^3. The biogas programs for households and groups have been established since 2007 in four (national) institutions which are Hivos, Ministry of Energy and Mineral Resources (MEMR), Ministry of Agriculture (MA), and Ministry of Environment and Forestry (MEF). These key institutions and the stakeholders related to their biogas programs are populations of this study for data collection.

3.1 **Data Collection**

This research utilized two types of qualitative data which are interviews and document review from formal policy documents, project reports, refereed scientific publications, professional publications, and knowledge products from related institutions. For the first sub-research question, qualitative data from interviews and supplementary desk research are gathered. The result becomes the evidence for the following sub-research questions. The result contains the information for determining examples at the local level. The data collection was also conducted in the local context because the indicators used in the conceptual framework (Table 3) include the involvement of local government. Jawa Barat province is chosen as an example of the involvement of local government in biogas programs because this province has a high rate of fragmentation of biogas programs in provincial and regency/city level (YRE, 2018).

In the second and third sub-research questions, the evidence also came from interviews and document review. These different sources bring complete benefit from various methods. All methods were undertaken until a saturation point was reached. The saturation point is defined as a condition when the same information is heard for three times from different sources or methods.

Twenty-two semi-structured interviews were conducted during the field work and it was recorded for data analysis. These interviews consisted of two phases (Figure 2). Purposive sampling and snowball sampling technique were utilized for the interviews. The first phase used purposive sampling technique because several contacts about the biogas programs were already derived by the researcher from previous work experiences. To gain extra information from other stakeholders, the second phase utilized snowball technique from the first phase. Sources from representatives of various stakeholders were chosen in different biogas programs with a specific purpose that fits for this research objectives. There is more than one stakeholder per program that comes from different types such as the government, businesses, civil society, and academics, to balance the information. In addition, two ministries who oversee coordinating national policies and its implementation were also interviewed, to find information about the roles of those institutions in biogas policy and governance coordination. Table 4 provides an overview of interviewed stakeholders. More detail information about the list of interviews is available in Appendix 3.

Table 4 Overview of interviewed stakeholders

Related stakeholders >		**National Government**	**Local government**	**Private sectors**	**NGO**	**Civil society**	**Academics**
Key institution	**Programs**						
Hivos	BIRU	Ministry of Energy and Mineral Resources	Agriculture agency, Bandung regency	Construction Partner Organization; Yayasan Kontak	YRE	Loan partner organization; Local Farmers cooperative; KPSBU	su-re.co
Ministry of energy and mineral resources (MEMR)	RE programs	MEMR • Directorate of bioenergy • Research center of RE	Energy agency, west java	PT SWEN	Hivos, YRE		Directorate of research and community development, University of Indonesia,
Ministry of Agriculture (MA)	BATAMAS, UPPO	MA • Directorate of livestock • Directorate of agriculture infrastructure • Task force on climate change in MA	Agriculture agency, Bandung regency	PT SWEN			Bogor agriculture institute
Ministry of environment and forestry (MEF)	Proklim, com-dev in the conservation area	MEF • Directorate of conservation • Directorate of climate change		PT SWEN			
	Coordination of policy planning and implementation	• Ministry of Development Planning • Ministry of coordinator of Maritimes					

For the interview questions, the topic list in Table 3 is utilized to guide the interviews. The specific topic list is put in appendix 1 of this report. The interview uses open questions (See Appendix 2). Each interview had a duration about one to two hours. It was done directly face to face in the offices of the institutions.

Data collection was done with the efforts to keep the reliability and validity of the information. To ensure the reliability of this research, consistent estimates or assumptions are given to the same phenomenon or indicators in each biogas program or institution. Same indicators, criteria, and data requirement were used and asked to each biogas program and confirmed to their related stakeholders. This way is utilized to keep the quality of the measurement procedure used in the data collection and conceptual framework.

In term of validity, the internal validity of this research is maintained by carefully linking the causal relationship between the indicators of fragmentation and policy output as the subject variables in the study (See section 2.4.2). Regarding external validity, the procedural variables are utilized to four selected institutions as the case study or as the representation of the generalizability of the study. According to Yin (2009), the generalization is not automatic, hence a theory must be tested by replicating the findings in several sites. Therefore, multiple inquiry methods are utilized. Meanwhile, Creswell (2017) argued that qualitative generalization is not always necessary since this inquiry is not to generalize findings beyond study area, but to study particular themes developed in the context of a specific case.

To construct the validity, multiple sources of evidence are triangulated to minimize bias in the result. To examine the natural situation, relatively new people or representative of stakeholders are chosen for the interview to make the research is more credible and objective. The work experience and network in the related field owned by the researcher are utilized in choosing the new people to be interviewed.

3.2 Data Analysis

This research utilized a qualitative analysis method. This method is an interpretative research which involved multiple forms of qualitative data (Creswell & Creswell, 2017). Figure 2 shows toolkit for guiding the implementation of an integrated method and conceptual approach.

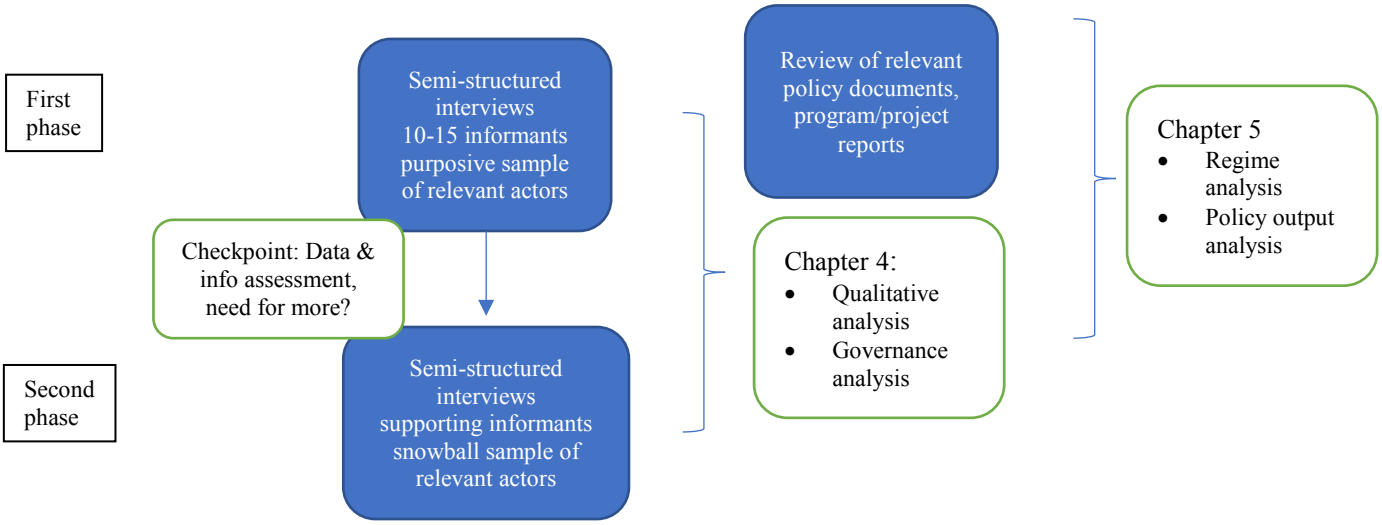

Figure 2 Toolkit of the integrated method and conceptual approach

In the first phase and the second phase, data from the interviews were organized to prepare the structure of the evidence. This data was organized through transcription of the interview results, scanning materials and typing up filed notes to understand the general sense of the evidence. Later for a more detailed analysis, a coding process was undertaken to generate a description of the situation and themes for analysis based on a topic list from the indicators in Table 3.

The coding process is a core activity in qualitative research (Creswell & Creswell, 2017; Silverman, 2015). Collected data was organized into several keywords based on the research questions, conceptual framework, and topic list. The first coding was done from the interview transcripts, policy documents, and program/project reports; to analyze governance arrangements from each biogas program and its institutions. Afterward, it was continued with the second coding, to analyze power distribution and coordination within the biogas regime, its governance architecture and the fragmentation, and the relationship with the output effectiveness of the regime. The final step is the interpretation of the data, which resulted in research findings.

Chapter 4. Biogas programs in Indonesia and barriers to biodigester dissemination

This chapter explains the existence of biogas programs in national policies in Indonesia. The existence appears in the implementation of various biogas programs in different ministries and in the non-state institution. The explanation in this chapter aims to provide an overview of biogas-related policies and programs, its governance arrangements, and the barriers to biodigester dissemination. This information answers the first sub-research question. These findings are the materials for the following chapter, to analyze the governance architecture of biogas regime and the fragmentation within it, to answer the other sub-research questions.

This chapter finds that there are only two general policy related specifically to biogas, which are energy mix and national climate change mitigation or NAMA (See 4.1). From those policies, the government utilizes voluntary biogas programs by providing grants from the government budget, foreign development aid, and funding from non-governmental bodies. The biogas program targeted the households and small community groups such as farmers groups and forest communities (See 4.2). Two types of governance arrangements are found in scattered biogas programs; 1. decentralized governance as the programs that come from the government bodies, and 2. Interactive governance, as the programs led by non-state actors in partnership with various stakeholders. These biogas programs have multiple dissemination barriers that are related to their governance arrangements (See 4.3).

4.1 Biogas-related regulations

There are two national regulations that are relevant to biogas dissemination in Indonesia, which are; 1. Energy mix target (legitimized in 2006 and renewed in 2017) and 2. The national climate change mitigation plan for climate change or NAMA (legitimized in 2011). Both regulations are related to the emergence of biogas programs

Energy mix target is part of national energy policy, that is formulated in national energy plan and local energy plan. Energy mix has the target of 10% of bioenergy by 2025. Within those plans, there is the target for biogas dissemination, yet it combines all scales of biogas, from large industrial scale to household scale. Besides, biogas for the household is also mentioned under the planning for small-scale energy (GoI, 2017). Yet, still, there is no specific target or number for household biogas and medium scale biogas. Besides to achieve energy mix target, the Ministry of Energy and Mineral Resources (MEMR) has biogas program also aim to reduce the cost of subsidy for kerosene and LPG.

Meanwhile, NAMA targeted to achieve the 26% (0.7 GtCO2e) emissions reduction target by 2020. Under the sector of agriculture and energy, biogas is included as one of the action plans to be done by Ministry of Agriculture (MA), Ministry of Energy and Mineral Resources (MEMR), and Ministry of Environment and Forestry (MEF) as implementing agencies. The national government estimated that the biogas usage will reduce of 1.01 million tonnes CO2e (0.001%). From this target, NAMA expected 0.13 million tCO2e come from 31,400 units of household biogas digesters with the volume of 5-6 m^3 (B. MEMR, 2016). One biogas unit of 6 m^3 capacity is estimated to reduce 3.2 tonnes CO2/year according to Gold Standard (Vorley, Porras, & Amrein, 2015). The biogas digesters are planned to be distributed to farmers households that own sufficient livestock and use fossil fuel (LPG) or non-renewable biomass (firewood) as their cooking fuel (B. MEMR, 2016). In the NAMA, biogas programs are only counted if it has the clear target and can be monitored, reported and verified, such as biogas programs from the MEMR and the MA (MEF interview, 25 June 2018).

Both regulations, energy mix target and NAMA are connected to the establishment of various biogas programs and projects in different institutions, to achieve the energy mix and emission reduction targets. Beyond energy mix target and NAMA, different motivations and problem background are also

found in the biogas programs in other ministries, such as the topics of waste management and forest conservation. The Ministry of Development Planning (MDP) recognized that the bioenergy programs, including biogas, are scattered in different ministries out of the MEMR, such as the Ministry of Agriculture (MA), and the Ministry of Environment and Forestry (MEF). In the MA, the motivation is to manage animal waste from beef self-sufficiency program, for converting cattle manures to be compost and biogas. In the MEF, the biogas program helps them for forest conservation, forest community development, and emission reduction. The biogas digester is introduced to prevent forest people using firewood (MDP interview, 4 June 2018). These different motivations cause the fragmentation of biogas-related policy results in scattered biogas programs in different institutions.

4.2 Biogas programs from different institutions

This section focuses on the biogas programs from four selected institutions, which are three government bodies (MEMR, MA, and MEF) and Hivos as non-government bodies. These institutions have the main small-medium scale biogas programs in Indonesia. In this section, general characteristics and output from biogas programs in four selected institutions are provided, to construct the analysis of governance architecture and the fragmentation in the following chapter. This section is structured with explanation per institution, then per program owned by the institution and its characteristics that consist of the general description of programs, key changes, partners for cooperation, and the dynamics within the program and/or the institution. Table 5 shows the summary of the characteristics and output of those biogas programs.

Besides the biogas programs from four selected institutions in this research, this research found that there are still many other biogas programs coming from several other ministries such as the Ministry of Public Works and Housing, Ministry of Villages, Development of Underdeveloped Regions, and Transmigration; Ministry of Women Empowerment and Children Protection, and Ministry of Cooperatives and Small-Medium Enterprises (MM interview, 25 June 2018). Some local governments also have their own biogas programs (YRE interview, 5 June 2018). This fact implies that the biogas programs are more fragmented beyond the scope of this research and the challenges for coordination within the architecture are more difficult.

Table 5 Characteristics of various biogas programs from different institutions (Source: Author's interviews and project reports)

	Key Regulation	Energy mix target, NAMA, & agriculture waste management						NAMA & forest conservation		
	Institutions	Hivos	MEMR			MA		MEF		
	Programs	BIRU	DAK/SAF	Communal biogas	Communal biogas	Batamas & zero waste	UPPO	Low carbon technology	Conservation area	Proklim
Characteristics	Implementing agencies	YRE	Directorate of Bioenergy	Directorate of Bioenergy	RE research center	Directorate of livestock	Directorate of agriculture infrastructure	Deputy assistant of climate change impact	Directorate of conservation	Directorate of climate change
	Partners	Local NGO, companies, cooperatives	BIRU, companies, local government	Companies, local government, boarding schools	The universities	Companies, local government	Companies, local government	Companies, local government	Companies, local government	Village government
	Funding	Foreign donors, the government, CSR, users	Government budget	Govt budget	Govt budget	Government budget	Government budget	Government budget	Government budget Community, CSR	Govt budget, local initiatives
	Year of program	2009-now	2011-now	2011-now	2005-2017	2007-2013	2008-now	2008-2010	2010-2017	2010-now
	Program approach	Market-based	Grant	Grant	Grant	Grant	Grant	Grant	Grant	Semi grant
Output effectiveness	The number of biogas digesters disseminated	22,000	6,000	3,000	<100	1,500	<100	No data	<100	1,000
	The assistance/ information provided	Pre-training, after sale service	Limited training and M&E	Limited training and M&E	Field training	In-house training	No training	Evening training	Capacity development training	No training for biogas

4.2.1 Ministry of agriculture

From 2007 to 2016, The Ministry of Agriculture (MA) had several biogas programs which are Batamas, Zero-waste livestock, and UPPO, in different (moving) directorates. From five directorates in the MA, three of them had biogas programs (Table 6). The target of their biogas program is the group of cattle or pig farmers.

Table 6 Biogas in the programs on different directorates in the MA (Source: Author's interviews)

The institution within the MA	Program	Year
Directorate of Processing and Marketing Agriculture Products	Batamas	2007-2014
Directorate of Livestock	Zero-waste livestock: Biogas, compost, liquid fertilizer	2010-2017
Directorate of Agriculture Infrastructure	UPPO	2008-now

4.2.1.1 Batamas

Batamas is an abbreviation that stands for 'Biogas program with the community'. It aimed to manage cattle manures, to provide side income for the farmers, and to support their energy provision. Batamas utilized the grant approach in which the biogas digester was given for free for the farmers, fully subsidized by the government. The farmers were asked to write a proposal to request biodigester, to the local government, and then passed to the ministry. From 2007-2014, under the Directorate of Processing and Marketing Agriculture Products, Batamas program disseminated 1592 biogas digesters in 30 provinces in Indonesia (MA, 2018). This program was recognized as one of the mitigation programs from the energy sector in Indonesian NAMA (CTF MA interview, 26 June 2018). Batamas used various types of the digester, such as fixed dome and plastic from polyethylene. The government spent about EUR 2,628 per unit biogas digester. The money was delivered through local government that worked with the construction partners from the company such as PT SWEN (MA interview, 7 June 2018). Batamas utilized decentralized governance arrangement, with the interaction between the MA, local government, farmers, and PT SWEN as construction partner.

The MA claimed that Batamas triggered farmers to be productive in doing waste management in the farms.

> *Batamas triggered farmers to be productive. After batamas, the farmers did biogas by themselves. They installed plastic biogas with the lower price, about EUR 140. This installation was done by local farmers, (MA interview, 7 June 2018, translated from Bahasa).*

Through Batamas, the farmers were expected to realize the benefit of biogas and to remain to continue using the biodigester. The farmers were also provided with knowledge through the provision of training about the use the digester. The training was conducted by the local research center of MA. The training was also given for free as part of the grant (CTF MA interview, 26 June 2018). However, the problem with the grant is that it makes the farmers do not have the sense of belonging to the biodigester. So, when the biodigester was broken, the farmers just left it without an effort to find the way to fix it (MA interview, 7 June 2018).

In 2014, Batamas stopped due to budget constraint and change of organizational architecture in the MA. Meanwhile, the Ministry of Development Planning or MDP (interview, 4 June 2018) said that Batamas stopped because there was another same program in another ministry and local governments that were more suitable to have the biogas program (MDP interview, 4 June 2018). After the program stopped, the MA estimated that there were only about 700 digesters that still work in 2015-2016 (CTF

MA interview, 26 June 2018). The MA also found that the farmers continued to install biogas by themselves, after Batamas. They installed plastic digester with the lower price (EUR 140). Yet, the quality was low and not sustainable (MA interview, 7 June 2018).

4.2.1.2 Zero waste livestock farming

After 2010, The scope of the biogas program falls under Zero waste practices in the agriculture sector. This concept has been actively promoted by the MA. The MA wanted to make use of agriculture waste for processing of compost and biogas and adding value to the livestock. So, the livestock manures can provide (side) income for the farmers while the farmers wait for the cattle to grow. Since then, biogas has been promoted to manage livestock manure and it has been introduced under Zero waste program. The biogas content hence was transferred from the Directorate of Processing and Marketing Agriculture Products to the Directorate of Livestock and Directorate of Agriculture Infrastructure (MA interview, 7 June 2018).

The Directorate of Livestock has a zero-waste program to facilitate the farmers' group to use their cattle manures for biogas, compost, and liquid fertilizer-in a program package. The biogas dissemination within the program was fluctuating based on the directorate's budget. Sharp decrease happened from 2016 to 2018. In 2016, there were about ten digesters and in 2017 there was only one digester because the budget was limited due to another priority (for cattle production program) from the Directorate; in 2018 there is no single digester installed. In total, there are about one hundred of biogas digesters from the Directorate of livestock from 2010.

Same as Batamas, the zero-waste program was also implemented through grant system and decentralized governance arrangement. The program utilized government budget (national and local budget), to install and to monitor the sustainable use of digester by the target group (MA interview, 7 June 2018). In 2016, the cost per program package was EUR 11,457. This cost also included the budget for monitoring and evaluation (M&E). The program provided technical assistance in form of in-house training about the use, processing, and the benefit of the digester. The in-house training was conducted in collaboration with the university, construction partner, and the MA research center. The directorate claimed that their biogas program also included the guarantee to the user, under the condition; the MA will fix the digester if the problem is caused by the technology, not from the user (MA interview, 7 June 2018). Yet, other actors such as local cooperatives and NGO argued that the MA program had no guarantee, many projects are being left after the installation, without providing the user about clear information or procedure about how to claim the guarantee (KPSBU interview, 12 June 2018).

Other characteristics of the zero-waste program are the same as Batamas. The program was delivered through local agriculture agency. In the beginning, the farmers' group are required to send a proposal to request biodigester, to the local government. Then, the local government reviewed and verified the proposal from the farmers' group. Afterward, the Directorate of livestock and the local government chose the target group through the screening process based on requirements that the farmers' group must fulfill, such as the ownership of the certain number of cattle and the ownership of cage that is closed to the house of the members of the group. In some occasions, there was another scheme where the local government proposed the potential groups to the ministry, to get the grant (MA interview, 7 June 2018).

The Directorate of livestock argued that the significant change in their biogas program might be in term of improving the requirements for the target group. The zero-waste program specified the requirement that the farmers' group must have the communal cage that is closed to the house of the group member, to ensure the biogas digester is really used and benefits them. The requirement also obliged the farmers' group to be registered legally, to apply for the grant. Besides, the zero-waste program was also better on the administrative part, compared to Batamas. The proposals in the zero-

waste program were sent online from the local to the national government. It increases the effectiveness of data management and helps the directorate to reduce the opportunity of overlapping grantees (MA interview, 7 June 2018).

4.2.1.3 UPPO

Another program from the MA who also has biogas feature is UPPO (Provision of organic fertilizer). From 2008, UPPO has been introduced to cope with the problem of infertile soil, under the policy for food self-sufficiency and organic farming. This program comes from the Directorate of Agriculture Infrastructure. UPPO provides the grant to the farmers' group in form of a package that consists of; cattle, compost house, and organic fertilizer machine such as chopper. Cattle manures in combination with other agricultural waste such as rice straw are used to produce organic fertilizer. Biogas is not compulsory for UPPO since it is not managed in the program guideline. But, some farmers groups in UPPO also use the manures for biogas, based on their own initiative (MA interview, 4 June 2018).

The strategy to operationalize the UPPO program is the same as the zero-waste and Batamas, which is decentralized governance. The UPPO is based on the proposal from the farmers' group to the local agriculture agency and delivered to the ministry. The difference is that UPPO involves more stakeholders in the program, such as the NGO, District Military Command/Force, and village supervisory non-commissioned officers, to help the program to install biogas. The MA used to work with the soldiers to support the food security programs (MA interview, 4 June 2018).

The directorate received about 2-3K proposals per year and granted 800-1000 proposals for all provinces. The cost for one package grant is EUR 17,186. Before 2013, each proposal received 35 cows in the grant package, but afterward, it was decreased to be 10 cows. Until 2016, the program has disseminated 2592 grant packages. However, there is no data about the number of biodigesters emerged from those grants. Although the directorate realized that the grant number shows a huge potential to use the cattle manures for biogas production, they choose to focus to their institutional focus on fertilizer (MA interview, 4 June 2018).

> *Due to their institutional priority, we must make our program focused on organic fertilizer, so we don't give training about biogas or not even monitor the data of own-initiative on biogas use, (MA interview, 4 June 2018, translated from Bahasa)*

The directorate estimated that from the distribution of UPPO in 34 provinces, the biogas may only exist in a few provinces such as West Java and Central Java (MA interview, 4 June 2018).

4.2.1.4 Transformation of approach to biogas

The MA argued that their biogas-related programs have some differences in locus, focus and the target group. This difference aims to avoid the overlapping situation where one farmer's group in a village to gain more than one biogas digester. The MA claimed that having different programs is a good strategy to be able to reach more farmers (MA interview, 7 June 2018).

This study argued that there is actually a transformation from those different programs. Batamas as the first program is a program that was really made for biogas dissemination. This program was listed as a mitigation action by the energy sector in NAMA (MEF interview, 25 June 2018). The zero-waste program from the Directorate of Livestock introduced biogas together with compost and liquid fertilizer. Biogas then was no longer the single main product. Meanwhile, in the UPPO, biogas is not even included in the compulsory guideline of the program. Biogas was just tentative side-product. This transformation shows that from biogas-related program to program in the MA, biogas becomes less

important content. Meanwhile, the MA was also focusing more to emphasize on other benefits of biogas such as to produce fertilizer from bioslurry. The MA argued that it was done to make people also pay more attention to their biogas digester (MA interview, 7 June 2018). The decrease of urgency or priority on biogas seems to cause the lack of innovation in biogas programs in the MA.

The significant change of abovementioned transformation was only more in bureaucracy processes, such as adding or specifying the content of requirement for the farmers' group to get the biodigester grant and the use of e-administration in proposal application. In addition, there is also light development on governance arrangement of biogas programs in the MA where there are more power distribution and cooperation with more stakeholders in the zero-waste and UPPO programs.

Currently, the sustainability of the biogas program in the MA is threatened to be disappeared, due to the decline of the approved budget for biogas. The Directorate of Livestock has put the biogas budget in their budget planning, but then the approval depends on the Minister of Agriculture and the Ministry of Finance to decide. Meanwhile, the MA priority for livestock is more to increase population and production of cows. The MA argued that the benefit of biogas is small, so biogas may no longer be taken into account. At the same time, The MA also realized that biogas is already handled by the MEMR (MA interview, 7 June 2018).

4.2.2 Ministry of energy and mineral resources

The national energy plan (NEP) gives mandates to the Ministry of energy and mineral resources (MEMR) to overcome energy poverty by diversifying household energy sources for cooking and to develop site-specific renewable energy resources (GoI, 2017). Diversifying energy source for cooking is required to deal with the LPG shortage and high-cost LPG import. To develop renewable energy use, the NEP created energy mix target. 10% of the share of energy mix target comes from bioenergy. Biogas target is mixed with other biofuels and biomass (MEMR interview, 6 June 2018).

Those mandates are implemented by the MEMR through biogas program as one of their energy programs. From 2007—2009, biogas was found in a few of self-sufficiency village program by the Directorate of Electricity in the MEMR. After 2010, the NEP mandates were done under the Directorate of Bioenergy, as part of the Directorate General of Renewable Energy (B. MEMR, 2016). This directorate general was established in 2011 to accelerate the progress of Indonesia to achieve the energy mix target. Besides, the MEMR also has the research center of renewable energy (RERC). Table 7 shows that the Directorate of Bioenergy and the RERC have biogas programs for the household and communal group (MEMR interview, 6 June 2018).

Table 7 Biogas programs in the MEMR (Source: Author's interviews)

The institution within the MEMR	Program	Year
Directorate of bioenergy	Household biogas program	2011-now
	Communal biogas program	2011-now
	BIRU	2009-2015
RE research center	Center of information and demonstration of biogas	2005-2017

4.2.2.1 The Directorate of Bioenergy

There are three biogas programs managed by the Directorate of Bioenergy; 1. The household program, 2. The communal program, 3. Collaboration with BIRU program by Hivos NGO. These three programs have been implementing during the same period of time.

The household biogas program

The household biogas program was started in 2011, right after the directorate was established. In 2011-2012, the directorate utilized national government budget for the program. However, from 2013, the funding source has changed to the local government budget and special allocation fund or DAK (SAF), managed by the Ministry of Finance. Same as the mechanism in the MA, this program utilized decentralized governance arrangement and the bottom-up approach through the proposal submission from the local community to local government, then reviewed by the MEMR. This process follows the national financial system for project funding. The MEMR claimed that they provide a short workshop about biogas from their research center to the local government (MEMR interview, 6 June 2018).

The strategy to operationalize the program is through direct physical development from the full grant, supported by the third party. To select the third party as construction partner, the MEMR held the open auction for vendors that can follow the standards for the program funded by SAF and biogas standard by the MEMR. One vendor can cover three regions or villages and the vendor has the duty to provide training to the user as part of the grant package (MEMR interview, 6 June 2018). Yet, the farmers' cooperative argued that it did not happen in the implementation because they found that the training was not always given by the vendor (KPSBU interview, 12 June 2018).

From SAF, the MEMR has disseminated 6363 household biogas digesters until 2017. The actual expenditures were not recorded by the ministry. The SAF is commonly utilized by some provinces such as Yogyakarta, Aceh, Jambi, and Lampung. In Eastern Indonesia such as Papua province, the MEMR tried to approach them, but they still did not send the proposal for SAF. This low participation in that area caused by different farming culture in the region in which the cattle are not organized in the cage. The farmers used to let the cattle live freely in the pasture or under the houses. This condition hampers the biogas dissemination in Eastern Indonesia (MEMR interview, 6 June 2018).

Communal biogas program

For the communal biogas program, it also has been started in 2011 using national government budget. This program has disseminated 3321 digesters, until 2017. Same as the previous program, it utilizes decentralized governance arrangement with the participation of local government, vendor, and civil society. The training for the user in the communal biogas program is done by the vendor. The training is more about how to use the biogas and it does not cover the technical detail such as fixing digesters, because it is done by the vendor itself. The vendor has the responsibility to fix digester during guarantee period of six months to one year. The MEMR also conducts the monitoring and evaluation (M&E) to the field at the end of the year by random sampling because they cannot afford to check all the biogas digesters (MEMR interview, 6 June 2018).

BIRU

Beside government funding, the MEMR also has the partnership with BIRU (Domestic biogas program) initiated by NGO of Hivos and YRE. The formal partnership happened from 2009-2015. Different with the full grant approach by other biogas programs, BIRU program subsidizes only 20 percent of digester cost. More explanation about this program is described in section 4.2.3. Currently, the extension of the partnership between BIRU and the MEMR is postponed.

> *Now, we don't have an official partnership with BIRU anymore because Hivos does not yet extend the MoU with the MEMR. Yet, the coordination among us still happens in form of synchronizing data about digesters and discussing technical specification for biogas technology standard, (MEMR interview, 6 June 2018, translated from Bahasa)*

The MEMR mentioned that this BIRU's commercial approach is not allowed to be implemented in the nature of a government financial system that requires the grant to be fully subsidized (MEMR interview, 6 June 2018).

The Directorate of Bioenergy claimed that there has been a significant change in the biogas program from the technical program. They have continuously reviewed specification of biogas technology and keep increasing it. The directorate also has improved the guideline of the program in term of the requirement for farmers to apply. The farmers must have the number of cattle that should be x+1 (x = minimum number of cows/pigs that able to produce manures to generate biogas). It aims to mitigate the risk of biogas stop operating or being used by the farmers due to the reason that cow is sold (MEMR interview, 6 June 2018).

After 2017, the MEMR mentioned that there should be no more other ministries having biogas programs because all the government funding for biogas is transferred to SAF. SAF for biogas program is centrally managed by the MEMR. This decision was confirmed by the presidential office based on the policy of one national data. But, the implementation of this policy still needs to be verified (MEMR interview, 6 June 2018).

4.2.2.2 The RE Research center

Besides in the Directorate of Bioenergy, the MEMR also had a biogas program from its renewable energy research center (RERC). The program is part of the center of information and demonstration of the renewable energy by the RERC. The RERC demonstrated and brought their biogas digester product to the community, through that program. It aims to empower the community by providing the grant of communal biogas digester to generate electricity, and gas for cooking stoves. From 2005 to 2017, the RERC had established the center of information and demonstration of the renewable energy system in the universities in the provinces of West Java, Jogjakarta, Lampung, East Java, Riau, and Aceh. The center promotes the RERC products, including biogas with the zero-waste concept that also produced bioslurry. The center of information and demonstration also aimed to disseminate biogas information to the students, especially in Sumatera, because biogas was not yet developed in the region due to the cultural barrier. Many people in Sumatera still rejected to use manures for energy because manures are seen as a dirty material that may affect the foods (RERC interview, 7 June 2018).

The RERC biogas program applied the combination of decentralized and interactive governance arrangement. The program worked based on the demand from the university who assisted villages and in coordination with local energy agency. Active involvement of the private sector was rare in the program because the RERC mentioned that as a public sector, they were not allowed to involve the private sector in the biogas program. The private sector only involved as the third party to the project through direct appointment by the government (RERC interview, 7 June 2018).

The communal biogas program in the RERC was different from the communal biogas program in the Directorate of bioenergy. The RERC admitted that there was no coordination between both programs. The synergy between both institutions was also not happened. The last cooperation was when the RERC wrote the report about the needs to reduce LPG use that caused the directorate does biogas dissemination from 2011. The RERC also had no coordination with Hivos or BIRU program. According to the RERC, that kind of partnership must be done by the directorate because it is Government to Government program between Indonesia and Netherlands without funding for research for the RERC (RERC interview, 7 June 2018). However, in fact, Hivos conducted biogas feasibility study in 2008 in partnership with the MEMR, without the involvement of the RERC (Hivos interview, 2 June 2018).

Separately, the RERC conducted their own biogas program. In 2011, the RERC constructed biogas digester in Lampung, with the raw material from waste from tapioca factory and it connected with the generator for electricity. The background of this project was the problem of smell from tapioca waste faced by the community around the factory. This program was done in collaboration with Lampung University who requested the cooperation with the RERC through the MEMR. In 2015, the research center granted the communal biogas, cattle, and fifteen household biogas digesters to the community in East Java who won the energy award held by the MEMR. The energy award program found that there are many good biogas projects, including from citizen initiatives and business innovation, such as from PT SWEN. In 2017, the research center had the partnership for biogas program with the university in Yogyakarta who also had an RE research center in collaboration with the farmers' cooperatives. This biogas program used cattle cages owned by the community member and the gas is spread to the community houses (RERC interview, 7 June 2018).

The research center did not have an integrated data about the number of biogas digesters been disseminated. They only have scattered data that records the dissemination of 10 household digesters and 4 communal reactors in Malang, and one communal biogas for each in Jogjakarta, Palembang, Aceh, and Lampung. The cost for one-unit communal biogas with the average size of 24 m^3 is EUR 17,186. This government cost for a biodigester is relatively more expensive compared to the cost from the private sector due to additional cost from tax, administration, and cost for the local consultant and Mason. The cost is also used for the field training that was conducted by the consultant, to teach the users about how to use digester and maintain the reactor. The RERC did not provide training anymore to the consultant from 2011, because the consultants have been certified by Hivos in BIRU program (RERC interview, 7 June 2018).

> *The local consultants that have been certified by BIRU, sometimes are smarter than us. They even criticized the biodigester design from us, (RERC interview, 7 June 2018, translated from Bahasa)*

The research center also did not provide M&E, the research center claimed that the M&E was organized by the community itself (RERC interview, 7 June 2018).

Regarding the significant change in the program, the research center said that there was no outstanding development. Technology remained the same, only PT SWEN who makes the biodigester with the longer durability, but the effectiveness is still similar. The biogas research is currently more about efforts to make gas stable and having high purity. Meanwhile, currently, the MEMR also has another priority in renewable energy, which is to make power plant from domestic waste and solar, not biogas. Now, the biogas program does not exist anymore due to a change in the organizational structure in the RERC. The RERC is currently having status as a public service body that is not allowed to install outsider technology. They are required to develop and to disseminate their own technology based on their research. So, the RERC must sell their products like reactor or act as the energy consultant. Due to this situation, the RERC started to think to have the partnership with Hivos or BIRU program (RERC interview, 7 June 2018).

4.2.3 Hivos and YRE

BIRU (Domestic biogas program) was established from the bilateral partnership between the Dutch and Indonesian government to develop long-term biogas sector. Dutch NGOs- Hivos and SNV facilitated the partnership from 2008 by conducting the feasibility study of biogas development in Indonesia (Hivos interview, 2 June 2018). The study found a positive result where biogas digester can be a productive sector by becoming a product with continuous supply and demand. Hivos hence initiated

the formal partnership with the MEMR (later appointed to The Directorate of Bioenergy), to create BIRU program. From 2009 to 2015, BIRU reports their yearly progress to the MEMR as part of the coordination (YRE interview, 5 June 2018). The implementation agencies of BIRU are Hivos, YRE (national NGO) and their construction partner organizations (CPOs).

4.2.3.1 Target and strategy

In 2009, BIRU started the program by targeting the farmers' households, to promote small-scale biogas as an alternative energy source to the old cooking fuel of kerosene and firewood. The use of biogas could save farmers' income about EUR 58 per month. At that time, the construction cost for installing biodigester was low, so biogas provided a strong incentive for the farmers. But in 2010, there was a progressive result from the government program in converting cooking fuel from kerosene to highly subsidized LPG. Meanwhile, the construction cost of biodigester also increased. Therefore, it made the incentive to use biogas decreased to be only about EUR 3 per month. So, BIRU looked for another incentive to promote biogas and they found it from bio-slurry which is the waste from the biodigester process. Bio-slurry can be used to produce organic fertilizer. Bio-slurry provides additional income of about EUR 116 per month for the farmers. This product is currently developed sporadically in some regions such as in Nusa Tenggara (YRE interview, 5 June 2018). Later, the development of bio-slurry led BIRU to work with the Ministry of Agriculture (MA interview, 8 June 2018).

From 2012, Hivos established a national NGO called YRE (Foundation of Home Energy). This action was part of Hivos strategy to develop biogas sector in Indonesia. In the long term, YRE is expected to be financial resilient and be independent of Hivos (Hivos interview, 2 June 2018).

> *Currently, the main income for YRE is still from aid funding. Yet, YRE is trying some strategies to diversify funding, such as building proposals to get funding, having other biogas programs other than BIRU, and create business wing or company to involve in government tenders, (YRE interview, 5 June 2018,* translated from Bahasa*).*

BIRU wanted to reach EUR 1 Million from carbon trading, so they made target to disseminate 100 K digesters by 2020 (Hivos interview, 2 June 2018). YRE realized that the target is over ambitious because the price of carbon selling mechanism is unstable (YRE interview, 5 June 2018). Until 2018, BIRU has only disseminated 22K biodigester in ten provinces in Indonesia and it provided revenue of 200K EUR from carbon trading.

Different from the government approach, BIRU utilized the commercial or market-based approach to sell biodigester to the community. Yearly, BIRU installs about 2500-3000 digesters and in ten years it may reach 25K digesters. Meanwhile, ENDEV (Energising Development)-as the donor- targeted BIRU to install about 4K per year, then BIRU had to choose whether to reach the quantity or quality target. BIRU hence decided their focus based on funding sources that must cover the direct and indirect cost of biogas project. The cost for one-unit digester is about EUR 600-1000. This cost is different for the biogas user from individual and/or corporate due to the existence of indirect cost for the corporate that includes the cost of organizational management. This cost supports YRE to deal with their financial resilient issue. To keep the market-based approach, BIRU asked the corporate to request the contribution from the community for biodigester installation cost, such as the community is expected to at least help the construction process. This approach was found working in Jambi province where the community helps in the construction process of biodigester (Hivos interview, 2 June 2018; YRE interview, 5 June 2018).

Beyond the small-scale, YRE also has the capacity to build the medium scale of 20m^3 digester that can be used for one neighborhood. Yet, YRE is not daring to target the sale for that product due to

market uncertainty. Despite there are many demands for it such as in Jambi province, BIRU chose to stay focus to on small reactor of 4m^3 on the ten provinces to commit to donor's target. This focus was chosen also because BIRU still must deal with the challenge in a province like West Java that experiences decreased the number of digester dissemination. In addition, BIRU has difficulty to expand their provincial coverage because they must have 500-1K demand for biodigesters, to make the revenue worth with operational cost (YRE interview, 5 June 2018).

4.2.3.2 Key change: partners for cooperation

BIRU tried to provide the solution to make people not depend on the government grant for biodigester and to provide access to biodigester for people who did not get the biodigesters grant from the government. BIRU implements interactive governance arrangement, with active interaction between NGO, government, and private sectors. BIRU derived various funding donors from several foreign development aids such as Endev and HEF New Zealand. Besides the donors, BIRU also did various schemes of partnership with several companies like PJT2, Medco, Pertamina, and Nestle. PJT2 wanted to clean the river to support their business. So, BIRU proposed the company to have corporate social responsibility for biogas programs that can help the company to clean the river from livestock manures. PJT2 agreed and this partnership also helped the company to gain a green image for their corporate. In Nestle, the partnership scheme involved farmers cooperatives as the provider of loan for the farmers who want to install biodigester. Another partnership is that BIRU worked with the banking sector to provide more competitive credits for people who want to buy biodigester. These partnerships expanded the range of potential customer for biodigester which is not only the household but also the companies (YRE interview, 5 June 2018).

There was an internal debate at BIRU whether they should work further with the government program or not. On one side, BIRU wanted to be different with biogas government program, on the other side- they also struggled with negative image from low-quality digester from the biogas government program that affects market demand on biodigester. Besides, BIRU also has funding constraints. Therefore, in 2014, BIRU chose to start the partnership with various government programs and utilizing funding from SAF or DAK (Government special allocation fund) and the local government budget. SAF provided the budget for the third party for the operational cost of biodigester installation. Hivos and YRE could not participate in the government tender for the biogas project due to the status of the organization as NGO. BIRU hence supported their construction organization partners (CPO) which are local NGO and companies to apply for tender of biogas projects by the government. BIRU works with, trains, and certify CPO from ten provinces in Indonesia, to install good quality biodigester. BIRU also supports CPO to do the intensive discussion with local governments to learn about tender procedures. When the CPO won the tender, BIRU utilized the budget for the cost of training for biogas user and salary for the mason in CPO (YRE interview, 5 June 2018).

BIRU also offered the government some changes in schemes of biogas program budgeting and establishing the MoU about it.

> *In South Sulawesi province, we do share budgeting with the government where we also provide subsidy as well for biogas project. In West Sulawesi, Hivos made the MoU with the local government to have funding partnership for biogas project. In West Nusa Tenggara, the government covered the training cost and cost of 20% subsidy in BIRU scheme,* (YRE interview, 5 June 2018, translated from Bahasa).

In Central Java and Bali, BIRU started to reduce the full subsidy from the government for biodigester installation, as the transitional strategy to disappear the subsidy in long-term, to build the real business

or market sector for biodigester. However, in some areas like in Sumba, the subsidy for biogas is still in big amount, due to low consumer buying power (YRE interview, 5 June 2018).

BIRU contributed to establishing the national standard in Indonesia for fixed-dome biodigester. This standard is adopted by the MEMR and projected to be applied to other biogas programs, especially biogas program by the MEMR that uses SAF (Special allocation fund). This standard is updated every year. The standard included the criteria for specifications of biodigester technology and technical guideline for installing biodigester. BIRU used to be invited by the MEMR for drafting the biogas standards, together with other representatives of biogas actors, such as practitioners and PT SWEN (YRE interview, 5 June 2018; MEMR interview, 6 June 2018).

Despite BIRU started to collaborate with different (government) biogas programs, the MoU of the partnership between BIRU and the MEMR was actually expired in 2015 and it is not yet renewed. YRE wanted Hivos to renew it, while Hivos and the MEMR expected the YRE to take over the MoU as the strategy to transfer BIRU from Hivos to YRE. The MoU works as the legal endorsement from the national government for BIRU (YRE interview, 5 June 2018; Hivos interview, 2 June 2018; MEMR interview, 6 June 2018). The MoU did not cover the coordination between BIRU carbon credit with Indonesian NAMA and its target, which still looks different to each other.

4.2.3.3 Dynamics in partnership

BIRU transformed the approach in the biogas sector that previously dominated by the government project-based approach. BIRU has built a market-based approach for the development of the biogas sector (MEMR interview, 6 June 2018). BIRU also chose to have more partnerships with the government bodies to support increasing quality of government biodigester and to fix public image toward biogas (YRE interview, 5 June 2018). This success is supported by CPOs. The CPOs did not only support BIRU for installing biodigester, but CPOs also manufactured the biogas appliances such as stoves and pipes, based on training from BIRU (YK interview, 12 June 2018). These CPOs derived income from the subsidy cost within the program, that was paid by BIRU. Slowly, BIRU is trying to reduce this subsidy cost because BIRU argued that theoretically there should be no subsidy in (biogas) business. The subsidy is projected to be replaced with a credit scheme (YRE interview, 5 June 2018).

Together with the CPOs, BIRU also provided information to the biogas users through workshop and training. In BIRU standards, training is compulsory within the program package. There were some partnerships with the government in conducting training, such as in South Sulawesi province- where the BIRU's CPO won the government tenders on biogas project. Another scheme for the training was cost sharing between BIRU and the government that was done in East Nusa Tenggara. Although the format of training is standardized, some CPOs are loose in conducting training. So BIRU must rebuke them to fix it. In 2017-2018, BIRU is chasing backlog from after sale services and training in their program. All provincial coordinators of BIRU are requested to call all CPOs to conduct training, monitoring, and after sale services (YRE interview, 5 June 2018; Hivos interview, 2 June 2018).

4.2.4 Ministry of environment and forestry

The MEF is the merger between the Ministry of Environment (ME) and the Ministry of Forestry, that was done in 2015. Table 8 shows three small-medium scale biogas programs that were found in the MEF, in different directorates (MEF interview, 7 June 2018). There is another directorate in the MEF that also has biogas content which is the Directorate of Environmental Damage Control. Yet, this directorate made use of domestic waste for large-scale biodigester, that is outside the scope of this research (MEF interview, 25 June 2018).

Table 8 Biogas-related programs in the MEF (Source: Author's interviews)

The institution within the MEF	Program	Year
The Deputy assistant of management of climate change impact (under the ME, before the ministry was merged)	Biogas for low carbon technology	2008-2010
The Directorate of climate change	Proklim	2010-now
The Directorate of Conservation	Community development	2010-now

4.2.4.1 Biogas program under the ME

From 2008-2010, the Ministry of Environment (ME) conducted biogas program under the Deputy assistant of management of climate change impact. There were some series of programs, but this program data was gone because of the change in the ministerial structures. In the beginning, this old biogas program did not include the aspect of methane reduction, the program was just to use a low carbon technology. After the rise of climate topic urgency in 2009, the ME added the aspect of emission reduction to the program. This biogas program utilized cattle manures that used to be dump to the river or left in the ground, by the farmers (MEF interview, 25 June 2018).

The program utilized a combination of decentralized and interactive governance arrangement. It implemented the grant-based approach and collective effort from the community. For example, in West Java province, there were 10 digesters given to 30 farmers in a dairy farmer cooperative. In the beginning, the 10 farmers cooked their cow milk with biogas and they were able to save money through that practice because it was decreasing the cost for LPG. The money was saved by the farmers in the cooperatives. Meanwhile, the rest of the farmers also did their own saving from their dairy product. Both sources of savings were combined, and the money was used to fund the installation of the new digester, for the rest of twenty farmers who did not have it yet (MEF interview, 25 June 2018).

The biogas program provided training for the farmers. Training was done in the evening because the farmers had to work in the afternoon. Training was done in the cooperatives or village office, with the content about techniques to operate and to maintain biodigester. The farmers were taught about technique for composing manures with water as biogas raw materials. From 2014, there was no longer particular biogas program in the ME, because the ministry had a new organizational structure, as the MEF or Ministry of environment and forestry (MEF interview, 25 June 2018).

4.2.4.2 Proklim

After 2010, the ME has the program of kampung iklim or the climate village (Proklim) in villages across provinces. This program is implemented by the Directorate of climate change with decentralized governance arrangement. This Directorate worked with the local environmental agency (provincial and regency or city level) in implementing the Proklim program. Proklim invited trainers or experts from various universities and research institutes such as ITB, IPB, UPN Yogyakarta, and LPTP Surakarta for knowledge transfer in the program. For technical support, Proklim empowered CPO or vendor, based on their availability to provide cheap and good technology. The directorate mentioned that they have no permanent vendor, but the most common one for them is PT SWEN. PT SWEN has been a vendor for the biogas program from 2008. This company installed biodigesters in several provinces, such as West Java and West Sumatera, funded by the government budget (MEF interview, 25 June 2018).

Proklim aims to identify climate action (both mitigation and adaptation) on the ground level such as villages or neighborhood. Proklim conducted the coordination, knowledge transfer, and introduction of low carbon technology, including biogas- to the village community. The program had no financial grant for technology. Proklim only triggered the awareness in the community about how to reduce GHG emission and let them decide their own initiatives to adopt the particular technology. To fund the initiative, some communities worked with the grant from NGO and external donor. Some villages chose to install biodigester because they had problems with livestock manures. The community was aware

that biogas provides multiple benefits; free renewable energy, liquid fertilizer, reduce the cost of LPG and increase social cohesion with neighbors. For the MEF, biogas helped them to support emission reduction and to increase the adaptive capacity of the community (MEF interview, 25 June 2018).

The directorate found that biogas is one of the most common technologies that is used by the community in Proklim. There were 1000 villages all provinces participating in Proklim, yet there was no data about the number of biodigesters on the program. The directorate only checked the number of biodigester in Proklim through the random visit for program monitoring. The visit monitored the capacity of the biogas reactor, cattle manures, and the degree of energy conversion.

> *"From the random check, we could only estimate that on average, maybe there was 1-2 biogas in each village in Proklim. There were also some villages with 40 digesters, but some of these villages had problems where 2 out of 10 digesters did not work"* (MEF interview, 25 June 2018, translated from Bahasa)

To validate the data, the directorate needs to visit all of them. But, the directorate chose not to collect data about the number of digesters because that data cannot be used to calculate emission reduction. It is because some biodigesters are not working or not used in some villages and it does not contribute to emission reduction. Besides, the MEF also had a limited budget to run a comprehensive monitoring and evaluation for the program. Therefore, the directorate just called that data as the potential of emission reduction from biogas (MEF interview, 25 June 2018).

Proklim did not belong to Indonesian NAMA (National mitigation action) because within the program, the community installed biogas based on their initiatives without having the exact target for emission reduction. NAMA is managed in province and ministry level, while Proklim is arranged in community level with no compulsory duty for the community, to install biodigester. The government sometimes helped the community to provide the biodigester in Proklim. Proklim did not want to provide cattle because the issue in which farmers sometimes just sell their cattle, then biogas digester is no longer used. This issue made the biodigester grant not so effective, according to Proklim (MEF interview, 25 June 2018).

The key change in Proklim is on behavior change from the farmers. For almost ten years, biogas programs have brought impact to the farmers to increase cleanliness in their livestock farm. Biogas has urged the farmers to organize their cattle manures. Farmers start to aware that manure is a potential material that has values, such as for biogas and fertilizer. Although some farmers did not have digester yet, they already know that they must collect their livestock manures (MEF interview, 25 June 2018). Yet, most of the farmers still rely on the government grant to get the biodigester.

4.2.4.3 Community development near conservation areas

Besides from the Directorate of Climate Change, the MEF also had related-biogas programs under the Directorate of Conservation. This directorate has a community development program in the regions surrounding the conservation area. Same as most previous programs, it utilizes decentralized governance arrangement, with coordination with local conservation unit and national parks. There are 102 community development programs under the local conservation unit, and 48 programs under National parks management. The target of the program is the community groups in the village such as farmer group, arts group, and mothers' group. The program aims to build the capacity of the community to develop potential resources of their region in a sustainable way, together with the conservation agenda. One of the potentials found is biogas from livestock manures (MEF interview, 7 June 2018).

The local conservation unit derived EUR 58,541 for the grant to regional community development. The grant utilized the bottom-up system, in the form of various capacity development programs that are needed by the community, assessed through participatory rural appraisal (MEF interview, 7 June 2018). There were several actors involved in the community development program. To install biodigester, the local unit hired masons and external worker, in coordination with village government. The local unit worked with local agriculture agency to get assistance from the external worker. Each community development program must ask for the permit from the village government. The local conservation unit also provided capacity development training as part of the program, that sometimes has the partnership with other institutions. Yet, there is no control or monitoring and evaluation of the implementation of the training in the ground level. This program has no partnership with BIRU because the Directorate did not know detail about BIRU (MEF interview, 7 June 2018).

From 102 programs, there were only two local units who reported biogas development in their region, which are Palian Gunung Kidul, Yogyakarta and Betung Kerihun, West Borneo. In Yogyakarta, the project was started in 2016 with full funding from the government. However, the development was stagnant. In West Borneo, the community made use of pig manures for biogas from 2015. Previously, the pig was not put in the cage, after the biogas program, the community put the pigs in the cage to enable the operation of the biodigester. The early cage construction was not working because it used cement material for the pig cage that made the pig died. In 2017, it was changed, the new cage was built under the public traditional house. The biogas hence used the gas for public kitchen, not for daily individual cooking. This biogas project was supported by ITTO (international timber trade organization) with consultancy by PT SWEN, which was hired by ITTO (MEF interview, 7 June 2018). This process shows that the project was just based on trial and error without professional knowledge that should be able to learn from other success biogas projects.

Besides in Yogyakarta and West Borneo, biodigesters were also found near the conservation area in other places such as in Bali and Banten (Rare, 2010; TRANSrisk, 2017). The Directorate of conservation claimed that if there is biogas in another local unit or national park, it may be the case that they did not report to the directorate. In some cases, those biodigesters may also not work anymore.

> *The existence of biogas in the community development programs in the conservation area was detected from around 2010. We do not have the exact data about the number of biogas digesters been disseminated in all community development programs near the conservation areas,* (MEF interview, 7 June 2018, translated from Bahasa).

4.2.4.4 Coordination for climate action

Besides having own biogas programs, the MEF also controlled and checked some biogas programs from other institutions, to lead the coordination of climate change mitigation action from the livestock sector. The MEF identified several ministries with biogas programs, like the MEMR, Ministry of Public Works and Housing, Ministry of Women Empowerment and Children Protection, and Ministry of Coordinator People Welfare. The MEF found that those biogas programs work with various CSR schemes, such as working with private sectors near the location. In the hotel in Bali, the farmers supplied their organic vegetables to the hotel, and the hotel gave the farmers biodigester. The MEF recognized that their data is still not reliable because they could not cover all biogas programs that are spread in many institutions (MEF interview, 25 June 2018).

In the near future, the Directorate of GHG inventory in the MEF had the plan to conduct MRV (monitoring, reporting, and verification) for those biogas programs that utilize government budget. The MRV aimed to track national achievement for NAMA (MEF interview, 25 June 2018).

4.3 Fragmentation and biogas dissemination barriers

This section analyzes how fragmented biogas programs above related to multiple barriers to biodigester dissemination, especially on governance barrier. Table 9 shows the list of barriers showed in order of the supply chain process of biogas dissemination (from the production of biogas, consumption by the users-related to culture and knowledge issue on the community), and program-related barriers, link to funding, management, governance, and policy issues. These barriers are relevant to most of the biogas programs above.

Table 9 Common barriers for biodigester dissemination (Source: Author's interviews)

Production	Consumption (by the user)	Culture-education in community	Funding	Program management & governance	Policy
Some do not have the **cage** for cattle, to manage the manures (Eastern Indonesia)	Low **demand** (for market approach)	Low environmental **awareness**, lack of campaign	Limited (local) **budget** for dissemination and M&E	Ineffective program management, lack of **institutions** (and capable personnel)	No mandatory **regulation**
The **deficit of manures** (when farmers have to sell cattle for the economic reason)	No **incentive**	Lack of social **acceptance** to manures for energy (in some areas)		**Grant** approach does not create a sense of belonging by user	Unclear **target** and implementation plan results in fragmented practices
The high **cost of installation** (sometimes) not worth the benefits	Low operational **practicality**	Social practices in using **firewood**		Bottlenecks or gap in **implementation**	Lack of **approval** from the people's representatives council
Low **quality** of (some) **digesters**		Lack of community **involvement** for good institutional management		Lack of enforcement of SoP and **standards**	Not competitive, compared to highly subsidized **LPG** and electricity price
Limited producer of **appliances** such as stoves		Lack of knowledge and **skill** in maintaining the digesters		Lack of **monitoring** and evaluation (from national team)	Lack of **priority** to biogas focuses more on (conventional) large-scale energy generation
				Lack of **coordination** to exchange knowledge, among programs and among farmers group	

The Ministry of Agriculture (MA) mentioned that the Ministry of Development Planning (MDP) targeted to install 300K small biogas digesters (size of $6m^3$). The MDP divided the target to several ministries, including to the MA (MA interview, 7 June 2018). The MDP even said that the government actually needs millions of digesters to be disseminated. But, the target number of dissemination is sometimes based on budget availability from the Ministry of Finance (MA interview, 7 June 2018). In 2006, the National energy policy included biogas as part of energy development planning. However, the implementation of biogas development is not significant. Although the potential is abundant, yet in fact, there were only about 30K digesters of various sizes that have been installed. Even, not all of it has been utilized (MDP interview, 4 June 2018).

The data of biodigester dissemination number comes from the MEMR. The MEMR collected data from other biogas programs such as BIRU, and PT SWEN who worked as the third party to various biogas projects by ministries, the local governments, and non-state actors. The data showed that there had been 36,032 biogas digesters from those different biogas programs in all over Indonesia till 2017. This data also originated from the grant record and proposal disbursement (MEMR, 2018). The validity of this data was limited because of the absence of comprehensive physical monitoring and evaluation (M&E). The detail M&E could not be implemented because the local energy agency at the provincial level had limited resources of personnel and funding to check all biogas in their wide-range of areas. In Java, this task was helped by the coordination from the farmers' group, in partnership with YRE and Hivos who had good institutional management. The Directorate of Bioenergy mentioned that they plan to have detail M&E for the whole area to check biogas condition. Another limitation for data validity was because the MEMR could not collect data from the biogas program in other ministries such as the MEF and the MA (MEMR interview, 6 June 2018).

> *There are still many biogas programs from the Ministry of Villages, Development of Underdeveloped Regions, and Transmigration; the Ministry of Social, the Ministry of Agriculture, and the Ministry of Environment and Forestry, (MEMR interview, 6 June 2018, translated from Bahasa).*

So, the MEMR had limited reliability on data of biodigester dissemination because not all programs were recorded by the MEMR (MEMR interview, 6 June 2018).

Biogas policy has uncleared and different targets from the MDP, the MEMR, NAMA, and BIRU. It brings scattered implementation that results in fragmented practices. Various biogas programs above show that there is fragmentation in the implementation of biogas policy. This fragmented implementation leads to some barriers to dissemination. Moreover, fragmented biogas programs affected the capability of each program to tackle those barriers in biogas dissemination.

4.3.1 Production barriers

An important aspect of the production side is the technological issue. Many stakeholders mentioned that the issue in the biogas production was the cost of technological installation. The cost is relatively high for the farmers. The Ministry of Environment and Forestry (MEF) mentioned that the cost should be covered together by the government, NGO, donors, and companies CSR (MEF interview, 7 June 2018). Meanwhile, BIRU argued that the high cost reflects the high quality of digesters that could provide multiple benefits. Good quality of biodigester technology provides customer satisfaction for the user. There is a need to have a consensus about the appropriate cost (YRE interview, 5 June 2018). The cost problem relates to practicality issue in the biogas technology. The MA said that unavailability of practical technology like portable digester or portable media for transporting gas is a barrier to biodigester dissemination (MA interview, 7 June 2018). Yet, PT SWEN claimed that they

actually already have that technology. But, the problem was the government did not want to use it due to the budget constraint (SWEN interview, 26 June 2018).

Another problem to the quality of biodigester is the bad performance by some construction partner organizations (CPOs) in installing biodigester. Some CPO does not obey the guideline for constructing good quality biodigester. It resulted in the low-quality technology used by the user. This issue brought negative public perception toward biodigester. In addition, lack of producers for the appliances of biodigesters such as stoves and pipes became another barrier to biogas production (YRE interview, 5 June 2018).

In the farming regions, biodigester dissemination and biogas production are limited by the farming behavior in some regions like East Indonesia, in which the livestock is not caged, but it is spread in the meadow or pasture. This behavior makes the farmers have difficulty to collect the manure for biogas raw material (MEMR interview, 6 June 2018). For farmers who have the cage for their cattle, the issue is their behavior to sell the cattle when they need quick income for the family financial reason. This practice reduces the stock of manures for biodigester operation, so the biodigester cannot be used temporarily until the farmers have new cattle (KPSBU interview, 12 June 2018).

The Directorate of Bioenergy MEMR stated that biodigester dissemination cannot be massive because it only works for the livestock farming regions (MEMR interview, 6 June 2018). However, PT SWEN rejected the MEMR argument about limited applicability of biodigester.

> *We have produced biodigesters for non-agriculture wastes, such as for domestic waste and human manures. We also actively promoted the products to the government and private sectors, (SWEN interview, 26 June 2018).*

4.3.2 Low market demand

The issues on the production side of biodigester affect the market demand from the user (Su-re.co interview, 1 June 2018). People found that biodigester is not practical to use because it requires a lot of efforts to collect the manures, put it into the digester, and mix it with water, manually. So, many people rejected to commit to that timely efforts-to generate energy (DRPM UI interview, 25 June 2018). This rejection influenced low demand from the community to biodigester. This barrier became the obstacle to promote the biodigester (YRE interview, 5 June 2018).

Consumption barrier relates to social issues on the community. The low demand was also influenced by socio-economic acceptance of people to biodigester. The MEF found that biodigester was not really interesting for the community due to the community mindset about the manures. For instance, in Aceh, people are disgusted with the manures and they prefer to keep using the firewood. This choice was also due to the preference of local people who like the flavor of food that is cooked using firewood-stove (MEF interview, 25 June 2018). People preference and behaviors are affected by their social practices that lack environmental awareness about biogas benefits. Some cases showed that the farmers stopped using biodigester when their economic condition increases and they back to use LPG. Many people still require socio-economic incentive to use biogas (Hivos interview, 2 June 2018).

The renewable energy research center (RERC) in the MEMR argued that community involvement is important for biogas digester dissemination. This involvement triggers the community needs to run the biodigesters. This involvement can be managed through a good institutional management by running the partnership in biogas programs (RERC interview, 7 June 2018). This example could be seen in BIRU program that collaborates with the farmers' groups and exchange knowledge about know-how of biodigester. However, this practice was rarely found in other biogas programs that caused the user could not deal with the socio-technical problem in using biodigester (MEMR interview, 6 June 2018). Some regions also have no farmers group to support knowledge exchange about biogas (MA interview, 4 June 2018).

4.3.3 Governance barriers

Barriers to production, consumption, and social issues of biodigester relate to the governance aspect of biogas programs. Figure 3 shows the connection between those different topics of barriers to biodigester dissemination.

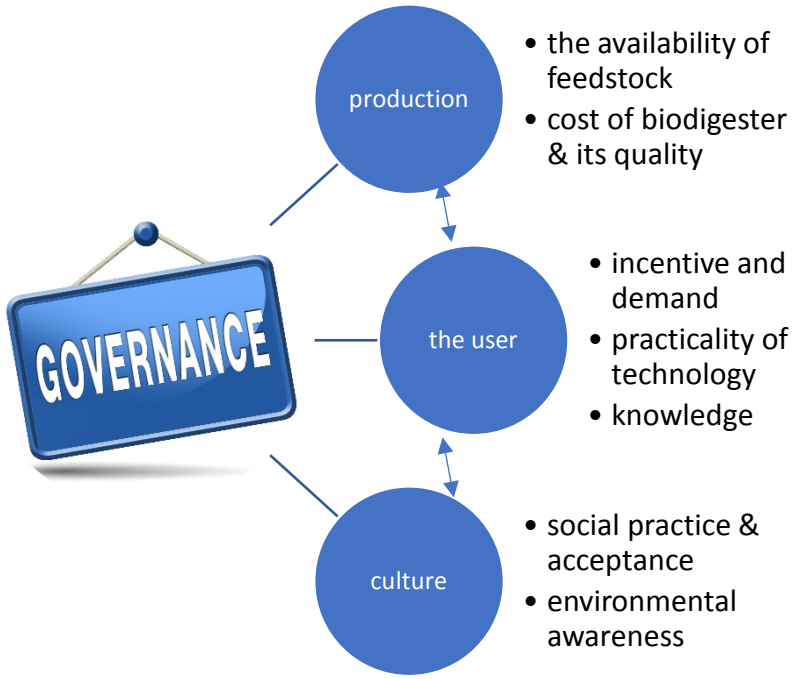

Figure 3 Linkages among the topic of barriers to biodigester dissemination

Barriers on production and consumption side are influenced by the governance problem within the biogas programs. Failure on planning and implementation of the program led to issues on program management on the field that connects to the users. The MA found that there were only a few members of farmer groups who had the understanding of biogas use, not all of them. It made the maintenance standards of biodigester were not consistently implemented in the program. This issue caused technical problems on some biodigesters (MA interview, 7 June 2018). Meanwhile, the government only conducted monitoring and evaluation (M&E) for about 1-2 times a year, based on the problem report from the user after installation. This effort was limited by resources such as time and the budget to cover wide-range of areas all over the country (MEMR interview, 6 June 2018). As a result, many biodigesters are left broken by the user and it affects public image about the technology. This issue influences the social acceptance of other people toward biodigester (TRANSrisk, 2017).

Meanwhile, the RERC in the MEMR said that the Government of Indonesia actually has the budget for biogas program (RERC interview, 7 June 2018). But the people's representative council also often did not approve biogas programs from the ministries in the budget planning (SWEN interview, 26 June 2018). This barrier to funding hampered the implementation of biogas programs.

The MEF mentioned another governance issue in the biogas program which is the grant approach by the government that provided the full subsidy of biodigester to people. Although it made people content to get free biodigester, the problem is that the grant also made them have the low sense of belonging to the digester technology. Many grantees did not really take care of their biodigester. For example, the behavior of selling cattle due to economic reason made digester goes useless. This problem is related to a low sense of ownership by the community to the free digesters (MEF interview, 25 June 2018). To tackle this barrier, BIRU tried to find consensus between the grant and the commercial

approach by reducing the amount of subsidy. Yet, the result of this effort was still limited in some biogas programs by the local governments (YRE interview, 5 June 2018).

Another governance issue was lack of coordination among biogas programs to exchange information about; best practices in production, creating demand from the consumer, program management and approach, and effective M&E.

> *Lack of coordination among biogas programs is caused by limited priority by the ministries to the program itself, so they did not put effort for the coordination, (MDP interview, 4 June 2018).*

The Ministry of Development Planning (MDP) mentioned that biogas alone is not the priority in the national energy planning. Biogas target could not be separated from other bioenergy types. In the roadmap for bioenergy plan, the priority is given more to biomass, bio-solar, bioethanol, and biodiesel. This plan was projected to be done in collaboration with energy companies such as Pertamina, PT PN, Medco, and Agri industries such as cassava, sugarcane, palm oil. There were many bottlenecks for the bioenergy implementation, such as difficulty in providing good fiscal or pricing that attracts private sectors and non-fiscal incentive to have support from the local government. The government currently focuses to solve it and thus biogas is not taking into account (MDP interview, 4 June 2018). This issue is linked to policy barrier to biodigester dissemination.

Indonesian renewable energy development (priority) and utilization strategy mentioned two focuses in relation to bioenergy; 1) Development of Bioenergy Power Plant including agricultural waste and municipal solid waste to provide electricity as well as to improve the environment; 2) Utilization of Biofuel for substitution of fuel oil (Finahari, 2015). The MEMR hence supported private sectors such as palm oil and tofu industry to develop biogas power plant. That strategy did not mention the small and medium scale biogas programs. The MDP said that solar and biogas is less prioritized because the result is small, despite the potential is big (MDP interview, 4 June 2018).

Less priority to biogas affected the budgeting in the ministries (MDP interview, 4 June 2018). The Directorate of Renewable Energy in the Ministry of Energy and Mineral Resources mentioned that since 2012, they had no funding from the national budget to continue household biogas program. The budget was cut because the national government wanted to focus on communal biogas program and other electricity programs. The MEMR argued that household biogas already has the mature technology, so they let the local government continue it. Alternatively, the MEMR utilizes local government budget and special allocation fund to fund the household biogas program (MEMR interview, 6 June 2018).

In the bigger context of renewable energy (RE), the government priority was more for the large-scale potential such as geothermal that has technology availability and able to produce large-scale electricity. This decision was taken by the government to achieve the target of emission reduction and electrification ratio. Meanwhile, the MEMR realized that renewable energy target in national energy policy will be difficult to be achieved (MEMR interview, 6 June 2018). The Ministry of Coordinator of Maritimes argued that the attention to RE is still relatively low because the government is actually still more focusing on conventional energy such as fossil fuel (MM interview, 25 June 2018).

These governance issues became a barrier for the coordination among the ministries, to resolve problems on the production, consumption, and social issues on biodigester dissemination. Therefore, fragmented government biogas programs remain ineffective without sufficient coordination.

4.4 Conclusion

Biogas programs are scattered in NGO and different ministries, such as the Ministry of Agriculture (MA), the Ministry of Energy and Mineral Resources (MEMR), and the Ministry of Environment and Forestry (MEF). In the MA, the motivation is to improve the management of agriculture waste through managing cattle manures for compost and biogas. For the MEMR, biogas program aims to reduce the cost of subsidy for kerosene and LPG and to achieve energy mix target. In the MEF, the biogas program helps them for forest conservation, forest community development, and emission reduction (MDP interview, 4 June 2018). Different motivations and problem background show that the biogas programs in those ministries relate to several policies such as energy mix target, NAMA, waste management, and forest conservation. It shows that the fragmentation of biogas-related policy is wider than energy and climate change policy. This wide fragmentation causes a lack of coordination among biogas programs.

Almost each biogas program stands alone. Two types of governance arrangements are found in those scattered biogas programs; 1. decentralized governance as the programs that come from the government bodies (MEMR, MA, MEF), and 2. Interactive governance, as the programs led by non-state actors in partnership with various stakeholders, such as BIRU. Few programs try to combine both governance arrangements, with a limited degree of interaction. These governance arrangements are part of the biogas governance architecture in Indonesia. The challenge for that architecture is to find the strategy to harmonize different biogas programs with different arrangements. to create an effective governance architecture.

Since almost all governmental biogas programs have similar governance arrangement, they have same characteristics, which are; scattered in different directorates or sub-institution within the ministry, using the grant approach, cooperate with local government and vendor, and do not have proper training and M&E. Meanwhile, the NGO program-BIRU utilizes semi-commercial approach; collaborates with multiple government bodies, construction partner organizations, cooperatives, and private sectors (companies and banks); and has standardized training and after sale services. The fragmentation triggers innovation in different biogas programs.

Within those biogas programs, there are multiple barriers along the supply chain process of biodigester dissemination (production and consumption-related to socio-cultural issues) and governance aspects. These barriers are relevant to most of the biogas programs. Barriers to production and consumption relate to the governance aspect of biogas programs; lack of knowledge on the users is caused by failure on planning and implementation of training and M&E; lack of coordination among biogas programs to exchange best-practices information reduces the opportunity to construct good quality biodigester installation, to create demand from consumer, and to have effective program management and approach; lack of demand is caused by the full subsidy approach by the government. In this situation, each institution requires coordination and cooperation among their biogas programs to tackle the dissemination barriers. Fragmented governance affected the capability of each program to tackle barriers in biogas digester dissemination. This issue is elaborated in the next chapter by analyzing the power distribution among institution and cooperation dynamics between program. This analysis defines the shift in architecture configuration of the fragmented biogas governance.

Chapter 5: Fragmented biogas governance and output effectiveness

In this chapter, the result from the previous chapter is analyzed to visualize the architecture of biogas governance in Indonesia and its changing configuration. This chapter utilizes inductive reasoning in which the premises are viewed as supplying some evidence for the likely truth of the conclusion. Section 5.1 shows evidence from the dynamics of power distribution and coordination within the biogas governance architecture. These pieces of evidence become the indicators to define the degrees of fragmentation within the architecture, in section 5.2. This section 5.2 also analyzed how the fragmentation affected output effectiveness of biogas programs and the regime. In addition, this section analyzes the influence of fragmentation on the projection of future biogas governance.

5.1 Biogas governance architectures

This section explains the existence of biogas programs in government structure (Figure 4) and the architecture of biogas governance itself for four selected institutions in this study (Figure 5). This explanation is followed by the evidence from the dynamics of power distribution and coordination within the architecture, in the sub-sections.

Figure 4 shows the architecture of the Indonesian executive government or the ministries. In total, there are thirty-four ministries, that consist of three level or categories which are; 1. five general ministries (secretary, development planning, bureaucracy, financial monitoring, and regulations); 2. twenty-five technical ministries (energy, agriculture, environment-forestry, etc.); and 3. coordinator ministries, e.g.; Maritimes (Detik, 2014). From this architecture, in the level of general ministry, the Ministry of Development Planning (MDP) was found involved directly in the planning of biogas target within national energy policy and NAMA or National mitigation action (MDP interview, 4 June 2018).

The governance architecture in Figure 4 is the structure from the 2014-2019's administration, yet it is not really different compared to structures in two previous periods of 2009-2014 and 2004-2009 (Detik, 2014). Biogas programs are still coming from the same ministries. In the last ten years, eight of twenty-five ministries or about 30% of technical ministries have had biogas programs. These programs even existed in different directorates or sub-institutions in some ministries. This situation implies that biogas programs have a high degree of governance fragmentation.

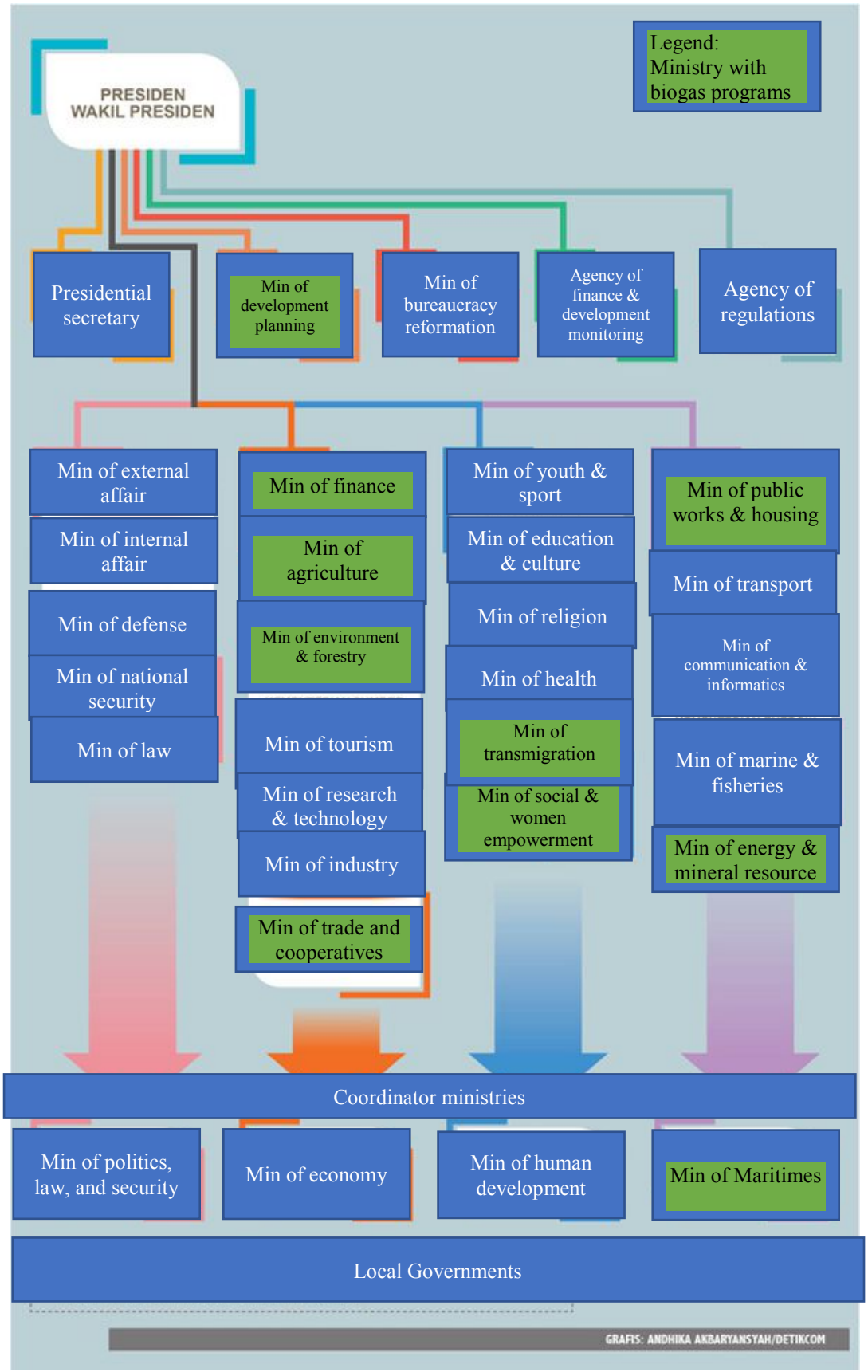

Figure 4 Biogas-related programs within Indonesian ministerial architectures (adapted from Detik, 2014)

In the technical ministries, there are eight ministries who have biogas programs and/or connected to biogas programs. These eight ministries are under three coordinator ministries, which are;

the Ministry of Economy, the Ministry of Human Development, the Ministry of Maritimes. Under the coordination of the Ministry of Economy (ME), there are four ministries with biogas programs, which are the Ministry of Finance, the Ministry of Cooperatives, the Ministry of Agriculture (MA), and the Ministry of Environment and Forestry (MEF). Under the Ministry of Human Development (MHD), the biogas program from the Ministry of Village and the Ministry of Social are relatively smaller compared to other biogas programs in other ministries. Meanwhile, under the Ministry of Maritimes (MM) who are responsible for infrastructure development, there are biogas programs from the Ministry of Energy and Mineral Resources (MEMR) and the Ministry of Public Works (MPW). Although there are only two ministries that have biogas programs under the MM, the size of these programs is bigger than biogas programs in four ministries under the ME. This fact shows that the priority for biogas is given more to the perspective of (energy) infrastructures (under the MM), less to direct economic growth (under the ME), environmental action, and human development (under the MHD).

According to the MEF (interview, 25 June 2018), and the MA (interview, 7 June 2018), there was no coordination from the Ministry of Economy about biogas programs to the ministries below them. The absence of the coordination might be caused by priority reason where biogas programs from those ministries under the ME were not considered as an important program. This kind of program is believed not contribute significantly to economic growth in the country. The same situation may also happen under the Ministry of Human Development, which is out of the scope of this research. Meanwhile, the MM conducted one meeting coordination about biogas programs with the MEMR and the MA (MM interview, 25 June 2018).

Biogas program does not only come from the national government, many local governments also have their own biogas programs which are not linked to national biogas programs from the ministries (West Java EMRA interview, 21 June 2018). Besides, Hivos (international NGO) has also established a biogas program since 2009 and it has been collaborating with government biogas programs since 2010 (Hivos interview, 2 June 2018). Figure 5 zooms in the architecture of biogas governance in Indonesia with more detail on each program and its implementing agencies from the directorates under the ministries and NGOs.

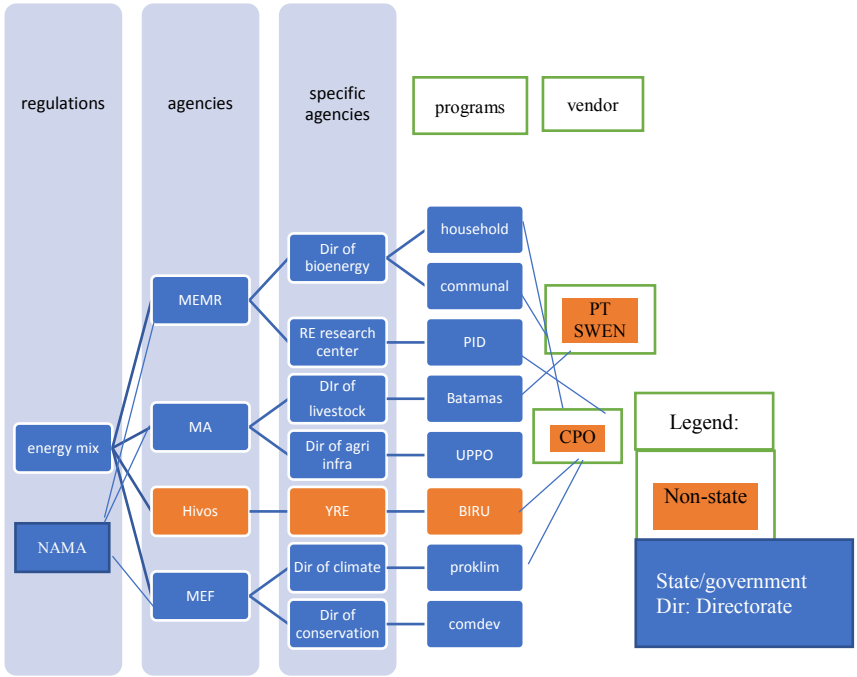

Figure 5 Architecture of biogas governance in Indonesia

Figure 5 combines the structures showed in chapter 4 about fragmented biogas programs from different ministries and NGO. Most of the biogas programs are interrelated to the regulations of energy mix and NAMA, except for community development program in the conservation area from the MEF (MEF interview, 7 June 2018). The architecture also shows that in each ministry, there is more than one biogas program spread in more than one directorate or sub-institution within the ministry. In the MEMR, the Renewable Energy Research Center (RERC) even also had separated biogas program from the Directorate of Bioenergy (RERC interview, 7 June 2018). Meanwhile, in the MA, the research center supported the implementation of biogas programs in the Directorate of Livestock (CTF MA interview, 26 June 2018). Many governmental biogas programs are also supported by a biogas business company called PT SWEN and construction partner organizations (CPOs) trained by BIRU program (SWEN interview, 26 June 2018). More analysis of these relationships among institutions is explained in the following sections.

5.1.1 Distribution of power

The fragmented situation happened at the biogas governance architecture in Figure 5. This fragmentation involves the distribution of power dynamics within the architecture. To analyze power dynamics within the architecture of biogas governance, this research looks at the institutional role of biogas actors and how power exercised by the actors. Figure 6 shows the dynamics of interconnected power distribution within the network of biogas actors. The distribution of power is analyzed and explored by looking at the distribution and utilization of three key resources: authority, finance, and knowledge of techno-scientific information (TRANSrisk, 2017). These resources are interlinked and connected to the topic of decentralization as one of the indicators in the conceptual frameworks of this research (Table 10).

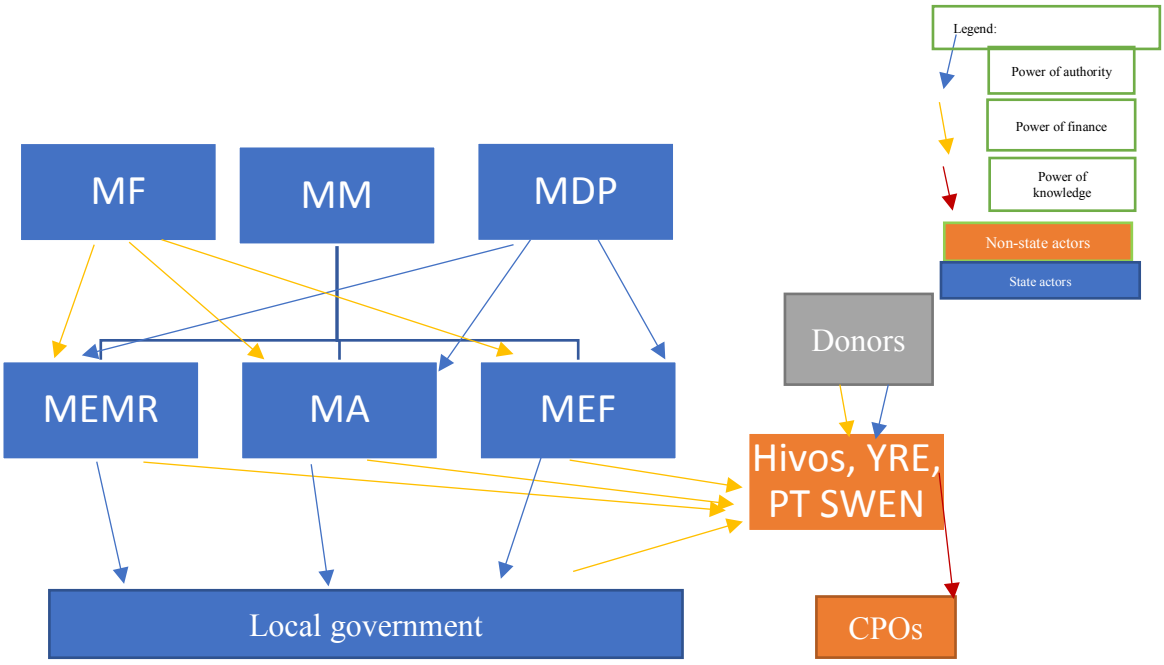

Figure 6 Distribution of power resources within biogas governance

Distribution of authority

In term of power to authority, two regulations of energy mix and NAMA have its chain of command to be implemented by the MEMR, the MA, and the MEF. The Ministry of Development Planning (MDP) oversees the planning of NAMA in the MEMR, the MA, and the MEF; and energy

mix target, with the MEMR (MDP interview, 4 June 2018). The authority relates to the topic of the target for the planning and implementation of biogas programs. There are three different targets found for biogas digester dissemination, coming from the MDP, NAMA, and BIRU. The MDP utilized their authority to enforce target for biogas digester dissemination to be achieved by the MEMR and the MA (MDP interview, 4 June 2018). However, Hivos and YRE did not know about the MDP and NAMA target on biogas, so BIRU has their own target. The MDP did not have the intensive coordination to communicate biogas target to Hivos and YRE (Hivos interview, 2 June 2018). As a result, there was no distribution of target for dissemination among different biogas programs from the state and non-state actors. Even within BIRU itself, there is power dynamics between Hivos and YRE in deciding target and running the program implementation (Hivos interview, 2 June 2018).

To enforce the implementation of (energy) policy planning, the Ministry of Maritimes (MM) is in charge to conduct coordination among the MEMR, MEF, and MA. However, it was only done intensively for the prioritized program by the government in which biogas was not included. The MM only held one coordination meeting about biogas with the MA and the MEMR. There was also no significant follow up from the meeting. The MM mentioned that the MA and the MEMR were afraid if the MM invited them for the coordination meeting because this kind of meeting implied the rise of duty for the technical ministries to increase the quality and quantity of their programs (MM interview, 25 June 2018).

From 2007 to 2016, the authority to run the biogas program and to achieve different targets is distributed in many institutions. But, in 2017, there was a change in power distribution of authority since all biogas programs are combined under special allocation fund in the MEMR (MEMR interview, 6 June 2018).

Distribution of finance

For distribution of power in financial resources, the MDP set several schemes for budgeting biogas programs, which are special allocation fund (SAF), public-private partnership (PPP), and purely from ministries' budget. The ministries can choose any scheme that fits with the context of their program (MDP interview, 4 June 2018). In the implementation, most of the ministries utilized the schemes of SAF and ministerial budget. The SAF scheme has the element of decentralization of power because it allows the local community and the local government to propose program budget based on local needs (MEMR interview, 6 June 2018). However, this power is limited by the authority of the ministries in deciding which proposals that will be granted. The hierarchical procedure for applying the biodigester grant seems to limit the distribution of power in financing the biogas program.

Despite the high amount of budget for governmental biogas programs, the farmers' cooperatives argued that those programs still have limited funding for monitoring and evaluation or M&E (KPSBU interview, 12 June 2018). Some ministries expected the M&E can be done with the local government budget (MEF interview, 25 June 2018). However, there were only a few local governments that implemented it. Many local governments rather choose to use their own budget to have another local biogas program (West Java EMRA interview, 21 June 2018). There is a distribution of financial resource between the ministry and the local government. These institutions have autonomy to decide the use of their budget.

Meanwhile, the national government utilized the financial instrument to track climate action programs, including biogas. The Ministry of Finance (MF) and the MA established the budget tagging tool that requires each ministry to tag their climate-related programs. This tool is expected to help to help the government to collect data about the distribution of scattered climate programs (including biogas), and to review its budget (MEF interview, 25 June 2018). This tool is expected to show data about the distribution of finance for climate-related programs.

Power distribution on funding affected the decision to choose the third party of government biogas programs. PT SWEN is a company who dominated the procurement of government biogas programs, from 2007. This domination happened due to the power relation between the owner of the company which is the spouse of the former director of livestock in the MA (SWEN interview, 26 June 2018). Yet from 2010, there has been more distribution of finance because BIRU was established in partnership with the MEMR. This establishment led the MEMR to share their financial power with BIRU as well. Besides, BIRU also derived financial power from international donors (YRE interview, 5 June 2018). This change reduced the domination of the government budget into biogas programs.

In power of authority and finance, there is no clear distribution of institutionalized functions and responsibilities among actors across biogas programs. From 2007 to 2016, the authority was distributed in various ministries, Hivos, and YRE. In 2017, it changed and left only the MEMR, Hivos, and YRE as the owner of biogas programs (MEMR interview, 6 June 2018). The power of finance follows changes in power distribution on authority because the legal power comes with funding to the program.

Distribution of knowledge

The power to techno-scientific knowledge about biogas becomes an issue in the government. In the RERC in the MEMR, their biogas program relied on BIRU's CPOs (RERC interview, 7 June 2018). It shows that the MEMR itself did not seriously develop biodigester technology with their own experts. Lack of knowledge about biogas makes some directorates within the ministries, local government, and the senators did not fully support biogas programs in development planning. The policymakers still lack knowledge about biogas benefits. This situation was getting better since the change in power distribution to the knowledge that happened since 2010. The establishment of BIRU distributed techno-scientific information about biogas to hundreds of CPOs and few local governments (Hivos interview, 2 June 2018).

Although the government and the donors dominate the power of authority and finance, the power of knowledge is acquired by the field implementing agencies such as YRE, its CPOs, and PT SWEN. These organizations have capable personnel that own knowledge and experience in biodigester technology and its installation. This techno-scientific information has been disseminated by BIRU to their CPOs in ten provinces in West and Central Indonesia, through various training (YRE interview, 5 June 2018). This action has disturbed PT SWEN's monopoly to biogas-related knowledge. Decentralized knowledge is not matched with the business logic of PT SWEN who produces fiber biodigester. PT SWEN chooses to centralize their knowledge expertise, for their dissemination in 30 provinces in Indonesia (SWEN interview, 26 June 2018). It makes the level of decentralization in accordance with the available knowledgeful personnel is still relatively low, especially in Eastern Indonesia.

The MEMR institutionalized the knowledge from YRE and PT SWEN, into the national standards for biodigester (MEMR interview, 6 June 2018). However, the MEMR has no authority to force other biogas programs in other ministries to comply with those standards.

To conclude, distribution of authority, funding, and knowledge about biogas within the governance architecture show that biogas regime is fragmented. But, it allows different institutions having various biogas programs and improve the speed of implementation. To increase the number of biodigester disseminations, the coordination among institutions to cooperate and collaborate is hence required. Cooperation to share power resources helps the result of the programs to be more effective. Biogas programs need to have the partnership with each other on the planning and implementation stage, to manage the joint responsibility, sharing funding, and exchange techno-scientific knowledge for

effective biodigester dissemination. The following section analyzes the coordination and the partnership among biogas programs and its actors.

5.1.2 Coordination and cooperation

This section looks at the actors' coordination, cooperation, and collaboration with each other. The coordination results in the various degree of partnership among biogas programs on the planning and implementation stage. The network of partnership among actors in biogas programs is related to the biogas socio-technological system. The networks within national biogas programs in Indonesia are built in this research. Figure 7 shows the network dynamics of coordination among biogas-related actors from 2007 to 2017. In Figure 7, the size of the actor circle represents the dissemination number of biogas programs from an actor, i.e. the more biodigester is disseminated by an actor, the larger the actor circle appears in the network map. The arrow appears if the actors perceived that they have coordination and cooperation in term of resources of administration/authority, funding, and exchange information relevant to biogas.

Source: Author's Interviews

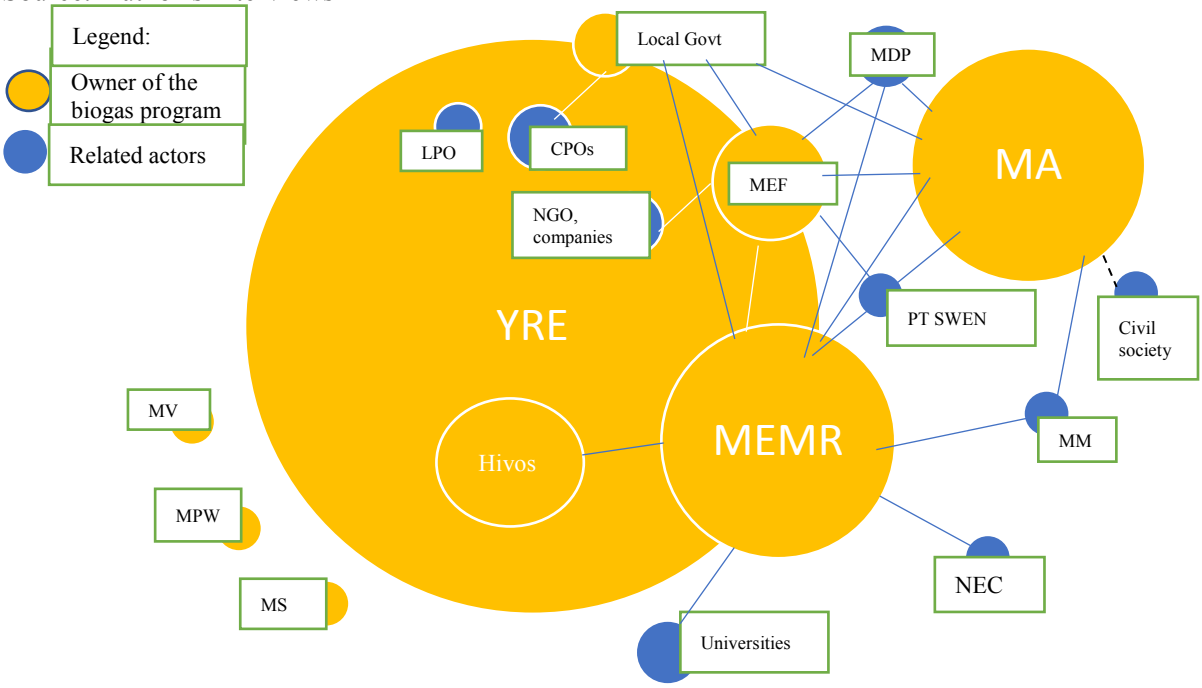

Figure 7 Coordination and cooperation among actors in biogas programs in 2017

The Ministry of Development Planning (MDP) that established the energy policy planning and NAMA, have coordination with the Ministry of Energy and Mineral Resources (MEMR), the Ministry of Agriculture (MA), and the Ministry of Environment and Forestry (MEF). Energy policy planning in form of energy mix target was issued by the MDP and the MEMR, in coordination with National Energy Council (NEC). The MDP claimed that there was coordination between energy policy planning and NAMA. The MDP invited the ministries such as the MEMR to align energy program under the NAMA with national energy policy (MDP interview, 4 June 2018). However, the synergy was not seen in the formulation of biogas target because different biogas targets were found in national energy plan and NAMA. The absence of involvement from non-state actor such as Hivos or YRE in the formulation of energy policy also made BIRU have the different target for biogas digester dissemination (YRE interview, 5 June 2018). Lack of coordination among distributed power in policy planning led to fragmented target in biogas digester dissemination. It results in the difficulty of converting different

targets in different related-policies into the specific target for biogas dissemination in different institutions.

Abovementioned condition led to the situation where the coordination happened randomly in the implementation stage. The MEMR had coordination with the MA and YRE to monitor data of biogas digester dissemination. To collect dissemination data, the MEMR invited the MA and Hivos or YRE for coordination meeting (MEMR interview, 6 June 2018). YRE works together with Hivos in running BIRU program (YRE interview, 5 June 2018). The MEMR (interview, 7 June 2018) found that in the MA, biogas dissemination data was scattered, and it must be collected from local governments. Meanwhile, the MEF also tried to have coordination with the MA and the MEMR, to collect data of potential emission reduction from biogas programs. But the MA did not provide it because the MA thought that they did not have that responsibility. To BIRU, the MEF did not collect data from Hivos and YRE because they considered BIRU as a non-governmental program. Yet, some of the biogas programs from the MEF hired BIRU CPOs (MEF interview, 25 June 2018). These findings show that coordination was done by each ministry alone based on their related responsibility. Some institutions even refused to cooperate due to the institutional ego. Institutional ego is a selfish attitude from the institution that avoids cooperation. There is no single integrated cooperation for collecting biogas-related data. This problem becomes a barrier to track and to evaluate the progress of biogas-related programs.

The MDP (interview, 4 June 2018) argued that the scattered coordination happened because of the nature of biogas has multiple benefits coming from different sectors such as energy, agriculture, and environment. In mitigation actions under the energy sector in NAMA, biogas falls under two activities which are self-sufficient energy village and biogas installation programs. NAMA includes the MA, the MEMR, and the MEF in charge for biogas programs (B. MEMR, 2016). The MA focuses on methane capture and the MEMR focuses on the strategy to use biogas to substitute for kerosene and firewood. The MDP combines these two measures and benefits, within the NAMA. The MDP recognized that the MA and the MEMR have different objective and priority in their mission in relation to biogas. The MA disseminates biodigester to improve agriculture waste management and the MEMR does it for energy security (MDP interview, 4 June 2018). Meanwhile, the MEF conducted biogas program to support emission reduction and forest conservation. Yet, the Directorate of Climate Change in the MEF (interview, 25 June 2018) admitted that the coordination between the biogas programs for emission reduction and forest conservation still does not exist.

Meanwhile, in national energy policy, it was mentioned that the implementation of energy programs should be cross-sectoral (GoI, 2017). However, the synergy among the institutions is still not effective (MDP interview, 4 June 2018). There is actually a mechanism for cross-sectoral coordination in the national regulation. However, it just encourages the institution to inform other-related institution about their program (MA interview, 8 June 2018). There is no enforcement in that regulation to force government bodies to have cooperation and collaboration for related programs, to perform more effective policy delivery. For example, the MEMR has provided the standard and technical guideline for biogas program. They also had coordination with the MA in establishing standard regarding the livestock condition. But, the coordination to enforce this standard to other biogas programs is still poor (RERC interview, 7 June 2018). There was also coordination meeting between The Ministry of Economy and the Ministry of Maritime with the MA and the MEMR to discuss biogas digester dissemination and its barriers, yet it did not result in clear task allocation (MA interview, 8 June 2018). These facts imply that there is still no effective cross-sectoral coordination and cooperation to support effective biogas programs.

The case of limited coordination about biogas also happened among directorates in the same ministry that has biogas-related programs. In the MA, although they have good cooperation between its research centers with the Directorate, the cooperation among two directorates that have biogas

programs- was not optimum to increase the effectiveness of biogas-related programs (MA interview, 4 June 2018). The same situation was also seen in The MEF where there was no communication among biogas programs in the Directorate of Conservation and the Directorate of Climate Change. Lack of cooperation also made biogas content in the Directorate of Conservation was just based on trial and error without professional knowledge that should be able to learn from other success biogas projects (MEF interview, 7 June 2018). The coordination was even worst in the MEMR in which the RERC in the ministry did not align with the Directorate of Bioenergy (RERC interview, 7 June 2018).

Beyond the aforementioned ministries, there are still more ministries that have scattered coordination in relation to biogas programs, e.g., the Ministry of Internal Affair that has coordination with all local governments in term of the budget mechanism. This coordination sometimes also led to budget conflict with the Ministry of Village that has the special allocation fund from the MDP (MDP interview, 4 June 2018).

Meanwhile, the MDP argued that coordination in biogas governance is still not effective because it is not the priority since biogas is only small piece within the environmental (NAMA) action and energy governance or energy mix policy (MDP interview, 4 June 2018). For example, the MEMR said that they have difficulty in supporting biogas because its scale cannot be massive, so the MEMR tried to combine it with another source such as bioethanol and dimethyl ether (RERC interview, 7 June 2018).

Although the MDP realized that the Ministries still need to have the active coordination for effective biogas dissemination, the MDP only suggested the moral support for the ministries to have coordination in biogas programs (MDP interview, 4 June 2018). They did not really utilize the regular meetings such as development planning meetings and other-related mechanisms, to have the effective coordination to improve policy delivery or output effectiveness of biogas programs. The awareness from the ministries about coordination is still limited to procedural practices, not yet to discuss the strategy to improve the quality of the development program through cooperation and collaboration. It was mentioned in this interview;

> *The coordination between the institutions in biogas programs is still hierarchical, from vendor to local government, and local to central government, to check the budget use and physical development, (The RERC interview, 7 June 2018, translated from Bahasa)*

For coordination among administrative levels such as from the national to local level, it is already regulated by the national financial system for budgeting government programs. This coordination scheme is set by certain standards, under national regulation. However, this coordination is also often not implemented well. Many government institutions concern more about the budget of the program, instead of the content. They wanted quick disbursement for their program, so they prefer to have a big project, to show and prove their performance. They also look at the location and number of populations that connects to success criteria of the program. The evaluation of the program is used to be done by the Ministry of Finance (MF) and the MDP. The MF looks at the scale and disbursement level and the MDP checks the impact of the program, such as to poverty number. Meanwhile, the biogas program is relatively small, and it takes the long process for its implementation and to reach success category. So, many government institutions skip the coordination, to derive quick disbursement for their biogas program (MDP interview, 4 June 2018).

In the local level, the local government was quite actively involved, almost in all national biogas programs. It includes local development planning agency, energy agency, agriculture agency, and environmental agency. In Proklim program by the MEF, the local environmental agency used to help the MEF to identify the suitable location for the program. The local agencies have better knowledge about village potential that can be granted biogas digester and cattle (MEF interview, 25 June 2018). In

the MA, the local agency acted as a technical team that conducts the program implementation and monitoring (MA interview, 4 June 2018). In coordination among the local agencies, the coordination is still limited in the context of location distribution, e.g., the energy agency consulted the agriculture agency about the location to install biodigester, to not having overlapped digesters in the same districts (West Java EMRA interview, 21 June 2018).

In short, the coordination among biogas programs in the government is still relatively low and scattered. Besides abovementioned reasons, almost all ministries mentioned that another reason is the existence of sectoral ego or institutional ego in each organization, either in directorate or ministry level. Some institutions tend to prioritize their institutional objectives above the national goals, e.g., the MA only focuses on beef production despite huge potential from cattle manures for biogas production (MA interview, 7 June 2018).

Cooperation with(in) non-state actors

Besides cooperation among the governmental bodies, the cooperation with non-governmental stakeholders also have several barriers and some dynamics of their partnerships.

The first barrier for the cooperation with non-state actors is the conflicting principle between the approach by governmental biogas program with the approach from NGO. Most government biogas programs utilize grant approach with full subsidy. Hivos and YRE argued that the grant approach led to counter-productive result for biogas sector. It did not create market demand for biodigester. Hivos and YRE also argued that the cost of government biogas program did not make sense because it takes too many external costs such as administration etc. (YRE interview, 5 June 2018). On the other side, the government also complained that BIRU digester from Hivos-YRE is expensive (West Java EMRA interview, 21 June 2018). BIRU argued that their expensive cost is used to maintain the high quality of digester (YRE interview, 5 June 2018). There is different objective between the government and Hivos-YRE. The government's vision pays more attention to the quantity, to install the digester as much as possible to reach the targets. While BIRU focuses more on quality. BIRU has a single target for dissemination and utilizing (semi) commercial approach, while scattered governmental programs have fragmented target and using only grant approach. These differences created disagreement and conflict within the biogas governance architecture from 2010 to 2014. It altered potential for cooperation becoming a competition. This change affects the structure of biogas governance architecture, to become conflictedly fragmented.

In 2009-2010, Hivos and YRE had limited coordination with the biogas-related government actors, in the initial stage of their BIRU program. Hivos and YRE were not involved and consulted in the process of establishing the energy mix and NAMA policy. From 2009-2012, BIRU only had coordination with the MEMR to kick-start their program (Hivos interview, 2 June 2018). BIRU faced difficulty to have coordination with other ministries. In 2013, BIRU had an intensive internal debate about the plan to cooperate with other government actors outside the MEMR. In 2014, BIRU decided to compromise with the government vision because BIRU also must reach the quantity target due to the expectation of the donors. Therefore, BIRU started to have the partnership with more ministries and the local governments (YRE interview, 5 June 2018). At that time, BIRU tried to approach the MA and the MEF, yet these ministries were not so welcome, so BIRU moved to the local governments, to mainstreaming biogas in local developments (Hivos interview, 2 June 2018). In 2017, BIRU did thirty-five coordination meetings with the government. All meetings were done with local governments, no national government such as the ministry (YRE, 2018). BIRU has increased the degree of coordination to transfer their knowledge resources about biogas to the government biogas programs.

The MA (interview, 7 June 2018) claimed that they did not want to have the partnership with Hivos because BIRU fixed dome digester was more expensive and not suitable for earthquake regions due to its fixed construction which is not flexible. Other reasons were because:

> *BIRU already worked with the MEMR and they work as the consultant, not a third party to provide digester. While we have to work with the third party or vendor, (MA interview, 7 June 2018, translated from Bahasa)*

The MA excused that BIRU is not matched with the national provision system for biogas program. But, BIRU's construction partner organizations (CPOs) is actually matched with the system. Some people in the MA claimed that they already have good biogas experts, so they do not really need BIRU (CTF MA interview, 26 June 2018). Some other people in the MA realized that BIRU has good training for the construction partner organization (CPO). But, still, they rejected to work with BIRU, except maybe only for discussion about biogas or for the provision of speakers for the training (MA interview, 8 June 2018). On the other side, BIRU has offered their CPO that fits with the government provision system, to work with the MA biogas programs. However, it was still rejected at the national level, but it worked at the local levels, such as in Bandung Regency (Bandung regency AA interview, 21 June 2018). The development of bio-slurry also led BIRU to work with the local agriculture agencies. This bio-slurry product is currently developed sporadically in some regions such as in Sumba, Nusa Tenggara (YRE interview, 5 June 2018). Later, the real reason is found why the MA did not work with BIRU is because the MA has been working closely with PT SWEN with power relation, from 2007. So, the MA sticks with PT SWEN as (permanent) vendor for biogas (SWEN interview, 27 June 2018).

Regarding the coordination with the non-state actor, the MA also has tentative coordination with civil society such as NGOs that monitor the biogas-related program. In the UPPO program, the NGO checks whether the grant package is delivered completely, or maybe something missing. The NGO used to talk with farmers group to evaluate the implementation of the program from the local government. If something wrong, then there will be coordination between the NGO with the local government and the ministry (MA interview, 4 June 2018).

The second barrier for the government to have cooperation with non-state actors is lack of knowledge by its personnel. The MDP has provided the scheme for the governmental program to cooperate with non-governmental actors (MDP interview, 4 June 2018). However, not all the government bodies perceived it. The Renewable Energy Research Center (RERC) in the MEMR did not know about the possibility to work with private sectors (RERC interview, 7 June 2018). Therefore, they did not work with the private sectors.

While the government limited their cooperation, BIRU has active cooperation with other actors, such as private sectors. Next to public finance, HIVOS and YRE also used to leverage funding for biogas uptake through micro-credit schemes. HIVOS and YRE started to work on micro-credit schemes through negotiations with credit unions for small credits. BIRU has signed a micro-credit agreement with Kiva, an international nonprofit lending institution (TRANSrisk, 2017). In some regions, BIRU also recognized other potential sources of funding to provide micro-credit for biogas development, such as the (CSR) companies that showed interest in giving incentives to (cooperatives of) farmers to adopt biogas as an eco-friendly technology to manage waste (YRE interview, 5 June 2018). To implement this strategy, HIVOS worked with the national government and banks to develop a larger credit scheme and a policy that forces provincial banks to allow credit for biogas development (Bedi et al., 2012). BIRU also has emerged hundreds of non-state actors as biogas actors, through training to the CPOs (Hivos interview, 2 June 2018). This cooperation has expanded the network of biogas actors and its collaboration for biogas programs.

Formal provisions to support coordination

Despite BIRU's progress, the overall coordination within biogas governance architecture is still scattered. This problem is caused by the absence of a clear national biogas-related policy in form of one single piece of a framework such as the national biogas plan. There is no creation of integrated biogas-related policy and/or institutions that can establish formal provisions to support coordination among organizations across administrative levels and sectors that have biogas programs. Therefore, there is no clear allocation of tasks and functions as coherent biogas programs and no clear cooperation that involves different institutions effectively. The government said that they do not have a single framework on biogas because biogas is not the development priority (MDP interview, 4 June 2018). In the context of renewable energy (RE), the government priority was more for large-scale potential such as geothermal that has technological availability and able to produce large-scale electricity (See 4.3.3).

Meanwhile, non-state actors have established two biogas associations; 1. The community of biogas Indonesia (founded by the ex-CPO of BIRU), 2. Indonesian biogas association (founded by the director of PT SWEN). These two associations are actively competing to lobby for biogas programs from the government and the companies (SWEN interview, 27 June 2018; YK interview, 12 June 2018). However, they do not have strong power in authority and finance to boost biodigester dissemination.

These dynamics reflect the trajectory of the development of fragmented coordination in the biogas governance architectures. After the close relationship between the MA and PT SWEN from 2007, BIRU and the MEMR started another partnership in 2009. But, this partnership was more open and formal. From 2014, BIRU even has invited other biogas programs to have collaboration with their program. At the same time, it also emerges the competition between BIRU and PT SWEN in biogas market. The absence of formal provision to support coordination leads to fragmented competition.

5.1.3 Summary

The distribution of authority, funding, and knowledge about biogas within the governance architecture show that biogas regime is fragmented. But it allows different institutions having various biogas programs, testing innovation, and improve the speed of implementation. This biogas regime does not have a single common target due to the absence of coordination in the planning stage. Yet, some coordination to cooperate and collaborate have been done by some biogas programs, in the implementation stage. Some partnerships managed to have the joint responsibility, sharing funding, and exchange techno-scientific knowledge for effective biogas digester dissemination.

Table 10 summarizes the dynamics or change of power distribution and cooperation in some period, within biogas governance architecture in Indonesia. The dynamics are based on the indicators used in the theoretical framework, that form the configuration of the regime, whether it is conflictive or cooperative. Lack of effective coordination within the distributed power triggers conflicted fragmentation. More cooperation and collaboration are required to harmonize the distributed power.

Table 10 Dynamics of coordination and distribution of power in biogas governance architecture (Source: Author's Interviews)

	Indicators	Dynamics among biogas programs from Hivos, MEMR, MA, & MEF	
		Before	After
Power distribution	Distribution of institutionalized functions, responsibilities, and power (resources: authority and finance) across programs	• 2007-2014: scattered programs in different institutions • 2009-2013: BIRU stands alone without the government budget	• 2014-now: BIRU compromise with donors and the government • 2016-now: centralization of governmental biogas programs to be under the MEMR
	Level of decentralization in accordance with the available personnel capability (resources: knowledge)	2007-2010: Domination of construction (expertise) from PT SWEN	2010-now: BIRU has trained about 100 CPOs in ten provinces. Knowledge resources are distributed
	The degree of partnership on planning and implementation (resources: authority, finance, and knowledge)	2008-2013: Each program stands alone	2014-now: BIRU has collaborated not only with the MEMR, but also with the MA, the MEF, & the local governments
Cooperation	The national biogas-related policy is coordinated/integrated into one single piece of a framework (i.e. national biogas plan)	• No (clear) cooperation between different biogas targets in the national energy plan, NAMA, and BIRU • An integrated framework is absent	
	Formal provisions to support coordination and cooperation among organizations across administrative levels and sectors: clear allocation of tasks and functions	• Coordination among administrative levels is regulated by the national financial system • The MEMR and the MEF has coordination with the MA to collect data of biogas dissemination & its potential emission reduction	2016, the MM facilitated coordination among the MEMR, MEF, & MA about biogas programs, yet not resulting in clear task allocation
	Involvement of local institutions in the creation of biogas-related institutions/programs	No creation of government biogas-related institution, but two biogas associations established by non-state actors	From 2014, BIRU has more cooperation with local governments, in mainstreaming biogas programs

5.2 Fragmentation, output effectiveness, and polycentric governance

This section utilized contents from the previous section about the power distribution and the coordination patterns, to define the configurations of biogas governance architecture. The configuration is identified using the framework of the fragmentation theory. Each configuration has different implication to the policy delivery or output effectiveness of biogas programs. In addition, the last part of this section reflects the configuration dynamics of biogas governance to the perspective of polycentric governance.

5.2.1 Fragmentation in biogas governance architecture

Based on the dynamics of power distribution and coordination within biogas governance architecture (Table 10), four shifts of regime configurations are identified during the period of 2007 to 2017. These configurations were shifting from 2007-2009, 2010-2013, 2014-2016, and after 2017. In those periods, the result shows that the dynamics of power distribution and coordination within the architecture reflect the various types of fragmented situation (Table 11). In 2007-2009, the biogas governance experienced administrative fragmentation. Then, from 2010-2016, Bierman's (2009) categorization of fragmentation, which is conflictive fragmentation and cooperative fragmentation happened. Afterward, from 2017 until now, the fragmentation has been reduced, neither conflictive nor cooperative.

Table 11 The degrees of fragmentation in biogas governance, from 2007 to 2017

	2007-2009	2010-2013	2014-2016	2017-now
Architecture configuration	Administrative fragmentation	Conflicted fragmentation	(Limited) cooperative fragmentation	Reduced fragmentation
Situation	Various ministries competed for the budget for biogas programs	BIRU cooperated with the MEMR, PT SWEN worked with the MA	BIRU extends the collaboration with other government biogas programs	All government biogas programs are projected to be centralized under the MEMR

In 2007-2009, various ministries including the MEMR, the MA, and the MEF had different biogas programs in their ministry. At that moment, the biogas program was still directed by different regulatory policies, such as national energy planning in the MEMR, integrated agriculture in the MA, and ecosystem conservation and climate mitigation in the MEF (MDP interview, 4 June 2018). In this situation, these different institutions seemed to compete to get bigger portion in national budget planning for their biogas programs. This condition reflected the phenomenon of administrative fragmentation where different government bodies have the same type of programs which is not integrated. The absence of the integration was caused by the inexistence of an overarching regulation that should trigger coordination among programs. The existence of biogas programs in different ministries implied the distribution of power, yet the absence of coordination among them became the obstacle to result in the more effective output of the program. The period of 2007-2009 is considered as administrative fragmentation also because, in those years, biogas programs were dominated by the government bodies, without significant participation by the non-state actor as the program owner.

In 2010, Hivos started to develop domestic biogas program (BIRU) in cooperation with the MEMR, to develop the biogas sector in Indonesia. BIRU introduced semi-commercial scheme as different program approach compared to the grant approach in the government biogas programs. BIRU also trained hundreds of local NGO and small companies to be construction partner organizations

(CPOs), to distribute techno-scientific information about biogas. In 2012, Hivos established YRE as national NGO to continue leading BIRU program (Hivos interview, 2 June 2018). BIRU distributed their power with coordination to many non-state actors. While the cooperation of BIRU with the government body was still limited to the MEMR. Other ministries such as the MA and the MEF still continue different biogas program on their own, with majority collaboration with PT SWEN as their dominant third party or CPO (SWEN interview, 26 June 2018). This situation hence led to competition between BIRU's group and PT SWEN's side. There are conflicting principles and rules of biogas dissemination between BIRU and PT SWEN. BIRU uses the technology of fixed dome digester and supports the (semi) commercial approach to deliberate biogas market in Indonesia (YRE interview, 5 June 2018). On the other side, PT SWEN utilizes fiber digester technology and benefits from grant approach from the government programs, to monopolize biogas market. PT SWEN wanted the government to intensively fund biogas dissemination (SWEN interview, 26 June 2018). BIRU complained to the grant approach because it became an obstacle to their commercial approach. Some people did not want to buy BIRU digester because they tend to wait for free digester from the government (YRE interview, 5 June 2018). The different principles between BIRU and PT SWEN are followed by their supporters and it reflects a conflictive fragmentation where the absence of coordination between two distributed powers was caused by contradicted ideas from both sides. This situation happened until 2013 and most of the government bodies stayed on their grant approach. Some of them mentioned that this choice was caused by administrative reason.

In 2014, BIRU decided to extend their collaboration and to adapt to other government biogas programs in the MA, the MEF, and local governments. This decision was taken to increase the quality of digester technology and to raise the number of biogas digester dissemination (YRE interview, 5 June 2018). This choice affected the fragmentation degree in the government biogas programs, moving from conflictive to cooperative fragmentation. Many local governments welcomed BIRU's approach to their biogas programs. Some government bodies hence started to have the formal partnership with BIRU, but some other such as the MA still preferred to remain working with PT SWEN.

Meanwhile, in the public-sector side, the government bodies also did not perform effective coordination and cooperation across sectors and levels yet. There was no significant cooperation between biogas programs in the MEMR, the MA, and the MEF (MDP interview, 4 June 2018). The cooperative fragmentation in biogas governance is still limited.

Competition remained between supporters of BIRU and clients of PT SWEN, yet some different principles started to adjust with market dynamics. Both parties stay in their own technological preference, but they were starting to diversify their business approach. After 2014, PT SWEN did not only rely on the government grant but also actively promoting their products to a wider market such as companies and individual users (SWEN interview, 26 June 2018). BIRU started to compromise with the grant approach but try to innovate the government scheme by reducing the subsidy from the government to the biodigester (YRE interview, 5 June 2018). On the other hand, more local governments cooperated with the semi-commercial approach (Bandung regency AA interview, 21 June 2018). The inclusiveness of those biogas programs added the degree of power distribution within biogas governance architecture. This situation located the configuration of the period of 2014-2016 closer to cooperative fragmentation (Figure 8). This configuration is not yet an effective cooperative fragmentation because the coordination between two conflicted actors still remains absent.

We tried to cooperate with BIRU, but it just did not happen because we have different technology and approach, (PT SWEN interview, 27 June 2018, translated from Bahasa)

They (PT SWEN) uses different technology (fiber digester) and works a lot with many government projects. I am curious about their motivation and vision, (YRE interview, 4 June 2018, translated from Bahasa)

Overall, the fragmented situation in the biogas governance from 2007-2016 was caused by several reasons; different motivations among programs and the institutions, institutional ego, and lack of coordination related to priority issue. In the government side, each ministry has the different motivation to their biogas programs, such as the MEMR for energy security, the MA for livestock manure management, and the MEF for emission reduction (MDP interview, 4 June 2018). For BIRU and PT SWEN, they have the different view about ideal biogas market whether it should be distributed or centralized by monopoly, to protect the quality (YRE interview, 5 June 2018; SWEN interview, 26 June 2018). These different motivations triggered institutional ego in which each institution wants to keep the (highest) benefits or budget for their own biogas program. Institutional ego in biogas governance also caused the lack of effective coordination among the institutions. For instance, the technical ministry such as the MA only wanted to come for a coordination meeting if the invitation comes from the higher ministry such as the MDP or the MM. The MA refused to provide data to the MEF (MM interview, 25 June 2018).

The coordination should be held by the MDP or the MM because they have more power and authority in the government architecture, not by the MEMR or the MEF, (MA interview, 7 June 2018, translated from Bahasa)

Another reason to lack of coordination is the priority concern. Many ministries recognized the point of the coordination, but they simply had no time to do it due to other tasks that are more prioritized in their ministry (MEF interview, 25 June 2018).

For biogas governance after 2017, the MEMR mentioned that all government biogas programs are projected to be united under the MEMR (MEMR interview, 7 June 2018).

From 2017, there are no more other ministries having biogas programs, because all (biogas programs) are moved to (under) DAK or SAF (special allocation fund scheme, below the MEMR). This decision was confirmed by the presidential office to follow national policy about one data-one policy. But, the implementation of this fact needs to be checked, (MEMR interview, 7 June 2018, translated from Bahasa).

One data-one policy is a national program to integrate all the same programs under the coordination of one ministry, to help the government to collect data about the program (MEMR interview, 6 June 2018). The implementation of this policy seems to happen because the proportion of biogas programs in the MA and the MEF are getting smaller and gone in 2017 (MA interview, 7 June 2018). This situation shows that the power of authority in government biogas programs is being centralized to the MEMR. The central government expected the one data-one policy to tackle the issue of coordination among government bodies. This policy implies the reduction of fragmentation degree within biogas governance. This trajectory may leave only the MEMR, BIRU, and the local governments in the configuration of biogas programs.

The single biogas program from the MEMR utilized the budget from a special allocation fund (SAF). The MEMR argued that the use of SAF could be a power distribution to local government and

it helps the MEMR to focus on other energy programs. The MEMR also argued the centralization in biogas aims to support national finance system. The fragmented situation makes data and M&E (monitoring-evaluation) of the programs separated or scattered and it becomes difficult for the Ministry of Finance for decision making of budget review (MEMR interview, 6 June 2018). Despite all the justifications, the centralization decreases power distribution among cross-sectoral institutions in biogas governance.

The centralization seems to be the reason as well for the MEMR to delay the MoU extension with BIRU. The MoU of partnership for BIRU between Hivos and the government finished in 2016. The MEMR mentioned that the Ministry of Social Work (MSW) is currently evaluating the decision to continue the partnership with Hivos as international NGO and the result will be out in September or October 2018. The MEMR said that they will continue the MoU if the MSW allows it. The MEMR expected BIRU will be continued by YRE and not depend on Hivos (MEMR interview, 7 June 2018). Although the MEMR stated that they may continue the partnership, but the centralization may affect the degree of partnership between the MEMR and BIRU.

5.2.2 Output effectiveness of the fragmented regime

This sub-section analyzes to what extent the fragmentation affects the output effectiveness of biogas programs in Indonesia. The output was measured from the number of biodigester dissemination and the existence and quality of training to biogas user, by the biogas programs. This collective output from different biogas programs was analyzed in the different fragmentation periods (Table 12).

Table 12 The policy output of biogas programs in four fragmentation periods

	Year period	2007-2009	2009-2013	2013-2016	2017
	Configuration	Administrative fragmentation	Conflictive fragmentation	(Limited) cooperative fragmentation	Reduced fragmentation
Output effectiveness of the regime	The number of (unit) biogas digesters disseminated (The MEMR, 2018; The MA, 2017)	800*	16,730	37,999	36,032
	The channel for providing information (training)	Limited training for users	Various types of training exist, in different approach and content	Some training was standardized	Not all CPOs comply with training standards

In 2007-2009, administrative fragmentation of biogas governance has implication to the availability of dissemination data of biodigester and the quality of the training to the users. There was no reliable data about the number of biodigester dissemination from the biogas programs in that period. There was only data from the Ministry of Agriculture (MA) that showed their dissemination of 952 units biodigester from 2007 to 2010 (MA interview, 7 June 2018). Therefore, this research estimated that there was about 800 biodigester disseminated until 2009. The MEF and the MEMR had no data anymore about their biogas programs in those years. They did not save the data (MEF interview, 25 June 2018). For the training, the MEF and the MA claimed that they provided training to the biogas users before the installation of the digester to the user. Yet, this training was conducted under the limitation of resources

from the government and limited time availability by the users. The ministry let the vendor provide training, and there was no monitoring and evaluation (M&E) from the ministry for the implementation of the training (MA interview, 7 June 2018).

In 2010, the conflicting fragmentation affected the output of biogas programs. There were conflicting principles between BIRU with the semi-commercial approach and PT SWEN that supported the government grant approach with the MA. On the one side, the government grant was slowing down the promotion of commercial biodigester by BIRU. The users tend to wait for free biodigester from the government, instead of buying subsidized biodigester from BIRU (Hivos interview, 2 June 2018). Besides, there was also conflicted dissemination location due to lack of coordination. The MA wanted the system of grantee candidate database to be used to collect data about the user who have received the grants. This system aims to avoid overlapping in delivery biodigester grant in the same location (CTF MA interview, 26 June 2018).

Despite the conflict, BIRU keeps tried to find other partners to work with. It resulted in the cooperation between BIRU and the MEMR. BIRU derived more donors and the MEMR gained more budget allocation for biogas programs, it caused more money being available for biogas dissemination. This partnership contributed to the increasing number of biodigester dissemination. BIRU's strategy to train CPOs also created more expertise on biogas builders (YRE interview, 5 June 2018). From 2010 to 2013, BIRU had installed about 11K digesters and the MEMR disseminated 4K digester. This contribution increased the total number of biodigester dissemination to be 16 K units (MEMR, 2018). The establishment of BIRU and the emergence of Directorate of Renewable Energy in the MEMR increased the degree of fragmentation to biogas programs (MEMR interview, 6 June 2018). This power distribution triggered speed of program implementation that resulted in the rise of the number of dissemination.

The fragmentation also influenced the provision of training in biogas programs. It caused various types of training to existing with different approaches and types of content. BIRU's training is followed with six months after sale services (Hivos interview, 2 June 2018). While the government biogas programs only provided scattered training in advanced, without the certainty of services after installation (MA interview, 7 June 2018). The existence of these training contributed to knowledge transfer about the use of biogas and its benefits.

In 2014-2016, BIRU's decision to expand the collaboration with the government impacted the output of biogas programs significantly. Conflicted fragmentation reduced and start to move to the direction of cooperative fragmentation that produced more effective output.

> *Biogas programs have existed from the government, (even) before BIRU (exists), but it was not massive because it used the project-based approach. BIRU has started to involve in it and fix the image of biogas in public. We need to continue it. There was a debate in internal BIRU whether we will join with more government programs or not. Finally, we choose to have the partnership with more government programs, to increase the quality of digester, to continue fixing public image toward biogas. From 2014, BIRU has started the partnership with more government biogas programs, (YRE interview, 5 June 2018, translated from Bahasa).*

Coordination of BIRU with more government bodies had effects on the output of biogas programs. This cooperative fragmentation increased the number of biodigester dissemination more than doubled in three years, from 16K in 2013, to 37K in 2016 (MEMR, 2018). The cooperation also affected the quantity and quality of training for users in biogas programs. BIRU made the standard for the training and it has been implemented in different related biogas programs (KPSBU interview, 12 June 2018). The standards were made by Hivos and YRE through BIRU program and it was delivered through training to many construction partner organization (CPOs). CPOs hence continued the knowledge

transfer through training to biogas users. These CPOs also applied the same standards when they worked with other biogas programs from the ministries and local governments (YK interview, 12 June 2018).

Since 2017, the significant change happened in the governmental biogas programs. All government biogas programs have been planned to be integrated under the MEMR. The MEMR claimed that this plan aims to ensure the quality of biogas to be aligned with the national standard (MEMR interview, 6 June 2018). Yet, there is not yet prove to it. The fact is that the centralization has reduced the degree of fragmentation, that decreased the biogas program output. The number of biodigester dissemination declined from 37K to 36K, in 2017 (MEMR, 2018). The centralization of power to biogas programs decreased efforts from other institutions to disseminate biogas digester. The budget for biogas programs in the MA and the MEF was reduced by the Ministry of Finance (MA interview, 7 June 2018). As a result, they conducted biogas programs with a limited budget that may affect the content of the biogas program. For example, the MEF did not cover the budget for training in their biogas-related program and the MA had a limited budget for training (MEF interview, 25 June 2018). This condition caused the situation where not all CPOs comply with the training standards (YRE interview, 5 June 2018). It reduced the quality of information received by the users, to maintain the biodigester. This limitation could bring back the past risk about lack of knowledge by the users in maintaining the technology.

5.2.3 Way forward to polycentric governance

This sub-section provides the projection for future biogas governance architecture in Indonesia, whether it can be transformed to polycentric governance or stay at centralized mode.

Some biogas actors realized that there has been fragmentation going on biogas governance architecture. Hivos (interview, 2 June 2018) saw biogas programs in Indonesia as a scattered policy that causes low quantity and quality on biogas digester dissemination. To change this situation, Hivos tried to embrace government biogas programs and pushing all cooperation opportunities. But, Hivos could not be ambitious with that effort because they are struggling with project funding for BIRU. Meanwhile, the government did not realize and did not really take into account the fragmented problems (MDP interview, 4 June 2018).

YRE (interview, 5 June 2018) regretted the situation of limited cooperation among biogas programs in Indonesia. It was seen as an unfortunate condition. YRE argued that biogas regime as a strategic sector should be in the configuration of cooperative fragmentation. The Ministry of Development Planning (MDP) is expected to lead the fragmented biogas governance. The MDP should have one grand design to reach several goals from biodigester dissemination through multi-sector approach (YRE interview, 5 June 2018). This suggestion is a form of cooperative fragmentation under a centralized coordination setting. YRE found that the biogas governance led by technical ministries such as the MA or the MEMR has limitation for cross-sectoral coordination due to strong institutional ego among governmental institutions (YRE interview, 5 June 2018).

The MA admitted that they put limited efforts to support the development of the biogas program. The MA had no intention to significantly boost biogas program (CTF MA interview, 26 June 2018).

> *Biogas is only sub or side product in our program. We have biogas to support programs of effective farming, with zero waste (principle). Biogas (digester dissemination) is not massive since it takes only less than 1 % of our ministerial budget. So, it is not so significantly good, (Climate task force-MA interview, 26 June 2018, translated from Bahasa).*

The MA expected biogas program owned by different ministries programs under the coordination from the MDP. The MA argued that the MDP has (authority) power with the NAMA (National Mitigation Action) to enforce biogas programs in various ministries for accelerating emission reduction (CTF MA interview, 26 June 2018).

According to Hivos (interview, 2 June 2018), The MEF and the MA may not have the push for the cooperation of biogas programs. For the MEMR, the push is the (energy) priority at the national level. The MEMR said that the coordination among biogas programs was not intensive because there was no budget for it, due to low priority for biogas agenda (MEMR interview, 6 June 2018). This low priority was also seen from the source of the budget for biogas which was from the special allocation fund (SAF), not from the national budget. But, YRE argued that the issues of priority and the cost of coordination are normative excuses. The government should take into account their commitment to reduce emission as a priority (YRE interview, 5 June 2018). Hivos said that they can lead the coordination to connect different biogas programs if they have funding for it (Hivos interview, 2 June 2018).

The MEMR (interview, 6 June 2018) mentioned that the coordination among ministries is also difficult, because the ministry often had personnel rotation, especially in the top-level position. This personnel rotation hinders the transfer of knowledge about the program. As a result, it becomes a barrier for conducting effective coordination. The MEMR argued that enforcing cooperative fragmentation is impossible because the nature of the ministries is 'hardly worked together' and did not have good coordination (MEMR interview, 6 June 2018). This issue was tried to be facilitated by Hivos and YRE through BIRU program.

From 2007 to 2016, BIRU had worked with multiple government bodies, companies, and local organizations. This cooperation is an improvement that increases the cooperative degree in the fragmentation of biogas governance. The improvement implied a transition from conflictive to cooperative fragmentation, to some extent. This change indicates a possibility to upgrade the governance model further to a polycentric governance. This model can bring a better distribution of function and effects to biogas programs. From 2014-2016, there had been an increase in the distribution of power to authority, funding, and knowledge in biogas programs. BIRU's decision to start the partnership with various government programs and using funding from SAF (special allocation fund from the government) triggered cooperative fragmentation as a way forward to polycentric governance. The gradual rise in power distribution can lead the biogas governance into an inclusive situation as an indicator of polycentric governance. The inclusiveness can lead to institutional fit among the biogas actors. The same condition also applies to the indicator of cooperation in which there had been more advanced coordination system, natural collaboration, and partnership among biogas programs, from 2009-2016. Further development of this progress can be a pathway to a coherent cooperation among biogas programs and its actors.

The MEF (interview, 7 June 2018) suggested that biogas programs in Indonesia should be connected by creating synergy among the ministries. The base should be the existence of 70K villages as a joint target for disseminating renewable energy. For example, in 2019, the MDP, the MEF, and the Ministry of Villages should lead the coordination to divide the responsibility among the ministries, such as the MA and the MEMR, to work on different villages. For the MEF, there are 2700 villages in surrounding the forest and 6000 villages near conservation areas. This synergy is not easy, it requires the willingness of the leaders in each ministry and the country itself (MEF interview, 7 June 2018). In addition, there are also other themes that can be used to establish coordination for biogas programs, such as the rural economy and environmental action (West Java EMRA interview, 21 June 2018). Those themes can be used by the biogas regime to increase the degree of cooperative fragmentation that can increase the output effectiveness of biogas programs for energy provision and environmental action.

However, policy change in 2017 seems to stop the transition of biogas regime to polycentric governance. One data-one policy by the government projected all biogas programs to be gathered under the MEMR (MEMR interview, 6 June 2018). This centralization is a way back from cooperative fragmentation. It reduced the number of biodigester dissemination in 2017 and it may continue to decline the efforts for biodigester dissemination from distributed power in government bodies. The centralized-power declines the opportunity for information exchange and collaboration across sectors. The MEMR argued that the centralized biogas governance aims to support the effort to enforce biodigester dissemination to comply with the national standard (MEMR interview, 6 June 2018). Yet, this implementation is still in doubt because the M&E in the MEMR itself did not happen effectively. The centralization may only change the administration and the distribution of power to the biogas program. The centralized biogas governance in the MEMR threatens the way forward of biogas regime to polycentric governance.

5.2.4 Summary

There have been shifts in the governance architecture of biogas regime in Indonesia, from administrative fragmentation in 2007-2009, conflictive and cooperative fragmentation in 2010-2016 with increasing degree of cooperation during the years, and reduced fragmentation after 2017. Figure 8 shows the shifts in the configuration of biogas governance within the period of 2007-2017, using the governance model quadrants. The shifts had implication to influence the output of biogas programs. The number of biodigester dissemination and the activity of knowledge transfer increased significantly during the period of cooperative fragmentation. In 2017, a new policy from the government reduced the power distribution within the architecture. This change contributed to the decline in the number of biodigester dissemination. At the same time, that change also stopped the transformation of biogas governance architecture in Indonesia to become polycentric governance.

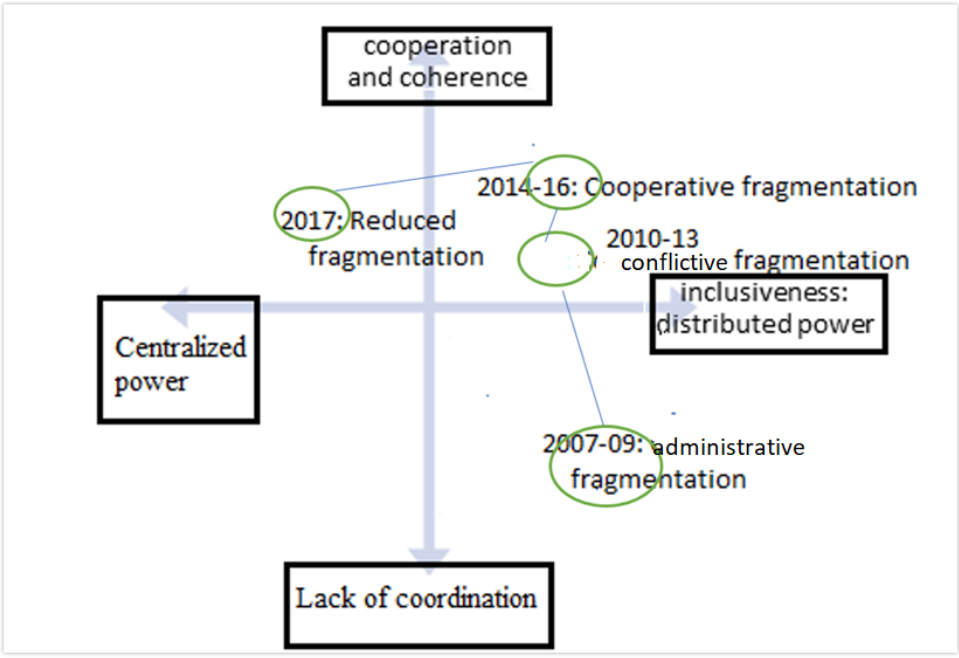

Figure 8 Periodical changes in the configuration of biogas governance architecture

5.3 Conclusion

The fragmentation within the biogas governance architecture makes frequent reference to changes in power distribution and cooperation. In different periods, there has been the dynamics of power distribution and cooperation within biogas governance architecture in Indonesia. The dynamics are analyzed based on the indicators such as decentralization, distribution of institutionalized function, the degree of partnership, and provision system for coordination. These indicators form the configuration of the regime, whether it is conflictive or cooperative. The absence of coordination within the distributed power triggers conflicted fragmentation. This situation happened in the biogas governance architecture in 2010-2013. Coordination and cooperation are required to harmonize the distributed power within the architecture. The more effective cooperation started to develop in 2014.

Those changes in power distribution and cooperation within the architecture form periodical shifts of configuration within the regime, from administrative fragmentation in 2007-2009, conflictive fragmentation in 2010-2013, and cooperative fragmentation in 2014-2016 with increasing degree of cooperation within this period. This shift had implication to affect the output of biogas programs. The number of biodigester dissemination and the activity of knowledge transfer increased. In 2017, a new policy from the government reduced the power distribution within the architecture. This change contributed to the decline in the number of biodigester dissemination. At the same time, it also stopped the transformation of biogas governance architecture to become polycentric governance. This topic is discussed more in the following chapter (See 6.2.2).

In the next chapter, these findings will be discussed together with the theoretical frameworks and method, from the perspective of broader literature. The causality between the fragmentation and policy output is examined, as well as the relationship between the fragmentation with polycentric governance, and the strength of the findings.

Chapter 6: Discussion

This chapter examines the strength of the findings, the theoretical framework and research method. The strength is examined by testing content from previous chapters to determine whether it agrees or disagrees with other literature. This chapter puts the research findings in broader debates in regard to the wider literature. This chapter is outlined in three sections: Section 6.1 discusses the empirical findings of this research, how could cooperative fragmentation work in biogas governance and beyond bioenergy topic. This topic is related to challenges to knowledge management and the need for coordination, to support decision-making for better policy output, whilst Section 6.2 reflects the use of theories in the research. Subsequently, Section 6.3 recognized a few reflections of the method in this research.

6.1 Beyond the fragmentation of governance architecture

This section discusses the broader context of fragmented governance architecture, not only regarding biogas in Indonesia but also its situation in other countries and for other environmental topics. Sub-section 6.1.1 discusses the interaction of different biogas governance arrangements under the nature of fragmented governance architecture. This sub-section also discusses the connection between fragmentation and the output of the biogas policy. Sub-section 6.1.2 highlights the findings from the alternative perspective of policy instruments and the correlation to its governance arrangement. Sub-section 6.1.3 concludes the key contribution from the research findings.

6.1.1 The fragmented governance architecture and the impacts

This sub-section discusses three interrelated topics related to fragmented biogas governance architecture. The first part shows the impact of fragmentation on decision-making. The second and the third part address the connection with the strategy of coordination. Subsequently, the final part reveals the effect of coordination on fragmented governance architecture, in relation to the output of the program and policy.

Knowledge for decision-making

The fragmentation of biogas programs in Indonesia triggers difficulties for institutions pertaining to collecting data concerning the number being disseminated, training and costs. This situation led to the condition of an information-poor environment. The lack of priority in relation to renewable energy could be the result of an endemic lack of information on which to base policy decisions (Smits & Bush, 2010). The existence of data is vital for decision-making on biogas policy (Budiman et al. 2018). For example, the methods of multi-criteria decision analysis require good quality data concerning energy supply systems from technical, economic, environmental and social aspects. Renewable energy like biogas has multi-dimensionality of the sustainability goal and involves the complexity of socio-economic and biophysical systems (Wang, Jing, Zhang, & Zhao, 2009). This multi-dimensional data is required for decision-making for renewable energy policy and governance, including biogas.

Knowledge and information from good quality data are essential for decision making. Data quality is determined by its accuracy, timeliness, relevance, completeness, trustworthiness and contextual definition. Good data quality requires effective data management and good governance to manage data effectively. Data management efforts are often hindered by the lack of clear responsibilities among actors and the lack of mandate and initiatives to carry out improvements in data quality. To promote effective data management, an effective governance strategy is required with the emphasis on collaboration across stakeholders (Cheong & Chang, 2007).

An example of governance strategy comes from governments in Anglo-American countries that sought to restructure their relationships with NGOs to deal with scattered programs, with the aim of designing effective governance architecture. This strategy triggered the emergence of new modes of control in the decentralization of various policy instruments and governance arrangements (Evans, Richmond, & Shields, 2005). The government and NGO could track the progress of various biogas programs by means of information and communication technologies such as e-administration to improve government processes, connecting actors, and building external interactions, such as those between the program providers and the users or consumer (Heeks, 2001). Currently, few governmental biogas programs in Indonesia make use of e-administration. Nonetheless, integration among platforms remains absent, especially with the non-governmental program.

Strategic factors for coordination

Integration requires coordination among various institutions, although, regarding the biogas actors, coordination is still absent. Singh (2013), argued that there are five strategic factors affecting coordination; specifically, the priority or commitment of top management, mutual understanding, relationship and decision-making, the flow of information, besides organizational f actors. He observed that the commitment of top management or priority is an essential strategic factor that leads to an agreed vision and the goal of the program or policy (R. K. Singh, 2013). The implementation of effective governance requires good coordination among the stakeholders. Subsequently, the issue is that the Indonesian governments have no willingness to conduct coordination for biogas programs due to the priority reason, as mentioned in sections 5.1.2 and 4.3.3. Coordination only has been undertaken for the prioritized development agenda in the government. Additionally, the status of priority appears to be crucial to force cross-sectoral synergy or coordination.

For the Indonesian government, the priority or principal commitment to the topic of energy for cooking remains the provision of LPG. To date, there is no specific transition plan to convert LPG to biogas or biomass gasification (TRANSrisk, 2017). In the context of bioenergy, the vision and goal are to install large-scale power digesters from crude palm oil and bioethanol. The energy policy in Indonesia, focuses more on biogas for electricity, while the use of biogas for cooking is scarcely discussed (Beaton & Lonton, 2010). Moreover, with regard to the government, biogas is not the main priority of the agenda for energy development. Therefore, the government is not initiating the coordination of biogas programs (See 5.1.2).

Should the lack of priority be the sole reason for the lack of coordination? Additional strategic factors should also be looked at in relation to coordination, such as mutual understanding, relationships, and decision-making, the flow of information, as well as organizational factors. Coordination is required for effective governance to result in optimum policy delivery. It could be initiated by a specific coalition of actors that has a mutual understanding and good relationships. This initiative can create alternatives to adapt to the existing system within the incumbent regime. Successful change in governance architecture requires the coordination of resources across diverse interdependent actors (A. Smith, Stirling, & Berkhout, 2005). In Indonesia, coordination among biogas programs could assist the Ministry of Energy and Mineral Resources to harness renewable energy resources and to achieve bioenergy targets within the energy mix policy. The coordination could even be completed at low cost and in an informal way, by using social media like WhatsApp group or using local mechanisms, for example, bonfire events. These examples have been practiced by the stakeholders in different fields, such as the platform for Green Districts in Indonesia that combined to establish the Roundtable for Sustainable Palm Oil Governance (Boyd et al., 2018). This approach is enabling the effective flow of information among the stakeholders.

The Green Districts platform is an example of successful coordination within fragmented governance. Nonetheless, the topic in the platform is the palm oil, which is an important economic

commodity in the country (Boyd et al., 2018), while biogas programs are aimed more at infrastructure purposes and have barely been integrated with the objectives of economic growth. This finding is identified by the architecture of biogas governance where most of the large biogas programs are under the coordination of the Ministry of Maritime Affairs who are responsible for infrastructure development in Indonesia (See section 5.1). Despite infrastructure being the priority for the country's current administration, the focus is more on large infrastructure projects for instance roads and harbors, and not on biodigesters (Warburton, 2016).

Lack of coordination caused the lack of policymakers' knowledge concerning the benefits of biogas policy product. Biogas has significant potential contributions for sustainable development. It has a positive effect on the national economy by integrating energy provision with rural development by disseminating cleaner fuel, valued added fertilizer and employment. The biogas digester is also within the capabilities of users because it can be constructed with local resources, whilst the community-scale digesters can even provide electricity and reduce the extension of grids. It can contribute to at least 10% of national energy demand and approximately 50% of rural energy consumption (Aye, 2005). However, these potentials are not sufficiently understood by policymakers (TRANSrisk, 2017), therefore, it discourages their attempts to utilize coordination within governance architecture. Although Indonesia is currently facing an LPG scarcity due to the rise in consumption and falling domestic production, biogas cannot yet play a role in substituting energy for cooking in farming regions (Thoday, Benjamin, Gan, & Puzzolo, 2018). This situation is also caused by the political business among the government and gas companies that maintain LPG as the main cooking fuel in the country (Beaton & Lonton, 2010).

The biogas regime in Indonesia needs to encourage five strategic factors affecting coordination; increasing the importance of biogas as energy for cooking, create mutual understanding among actors, strengthen relationships among biogas programs for effective decision-making and establish an information exchange platform among organizations. This coordination is required to increase the effectiveness of biogas governance for energy provision. The effectiveness could be improved by rebalancing sustainability approaches, by way of promoting the economic logic of biogas; the use of local resources can save foreign exchanges, limit exposure to fluctuations in international LPG market prices, while at the same time provide renewable energy. Notwithstanding, this promotion requires cross-sectoral coordination.

Building an integrated strategy: lessons from other countries

It should be noted that coordination is required to build an integrated biodigester dissemination strategy, either with rural energy management or other development agenda. This strategy requires effective coordination across sectors and levels to develop a detailed biogas governance plan. The integration could be conducted in several sectors such as environment and agriculture. There are several lessons that can be learned from biogas governance in other countries, about an integrated biogas governance.

Biomass accounts for approximately 15% of global primary energy consumption and it is an important energy resource in developing countries (Bassam, 2013). China is the world leader in biogas production (Yisheng, Minying, & Zhenn, 2002) and roughly 26.5 million biogas digesters have been used in the country (Bond & Templeton, 2011; Chen, Yang, Sweeney, & Feng, 2010). Countries in South Asia (such as India, Sri Lanka, and Nepal) also use biogas to a lesser extent. There are roughly 4 million biogas digesters operating in India, whilst the use of biogas is also increasing in Vietnam, Brazil, and Tanzania (Bond & Templeton, 2011; Mahapatra, Chanakya, & Dasappa, 2009). The promotion of biogas undeniably is not a quick solution. China needed more than 40 years to reach its current leading status. Biogas initiatives were promoted from the 1970s and its rapid development occurred in the 1980s via an integrated energy strategy and rural energy management. A detailed system of the management

plan was developed to implement the strategy (Bhattacharyya, 2012). In Indonesia, organized biogas promotion began in the 2000s and subsequently, development has increased in the last decade through (limited) cooperation within the biogas regime. Nevertheless, certain projects remain unsustainable. In 2017, the fragmentation was reduced, which in turn lessened the number of biodigesters being disseminated (See Section 5.2.2). Hence, biogas governance in Indonesia is still not integrated with coordination.

Coordination can also be undertaken by linking the co-benefits of biogas to environmental protection and climate change. As a substitute for firewood, the use of biogas saves the exploitation of fuelwood and reduces forest degradation (Aye, 2005). Concerning the climate, use of the biodigester reduces methane emissions (Cuéllar & Webber, 2008). The new generation of Indian National Bioenergy Cookstoves Initiative succeeds in reducing emissions by way of improving energy efficiency. The initiative avoided 570,000 premature deaths and 4% of India's greenhouse gas emissions (Venkataraman, Sagar, Habib, Lam, & Smith, 2010). This example shows the possibility of integrating different objectives in a biogas framework. Nevertheless, the aforementioned aspects are not really of concern to the Indonesian government. Currently, small-medium scale biogas remains a relatively small contributor regarding emissions reduction in Indonesia. This is caused by a lack of coordination and cooperation among programs in designing an integrated strategy. In South East Asia, energy policy is often driven by business interests, rather than by climate change concerns (Smits, 2016). Therefore, it appears difficult to integrate climate and energy policy. Consequently, the fragmentation in biogas governance continues without sufficient coordination and cooperation for integration.

Coordination can also be triggered by connecting biogas with the agricultural and economic sectors (Geels & Raven, 2006). In Indonesia, there has been changes and development in the direction of biogas technological trajectories, such as the promotion of the benefits of bio-slurry obtained from biodigesters. Bio-slurry connects biogas with economic resilience aspect within climate change adaptation- in terms of diversifying people's livelihoods that contribute to the economic objective. The economic motivations related to revenue generation through available feedstock that otherwise would be wasted. Bio-slurry can be the potential savings or income that could be achieved by using it as a synthetic fertilizer (a by-product of biogas) and replace chemical fertilizer (TRANSrisk, 2017). Bio-slurry and abovementioned different topics and sectors can be utilized to trigger coordination and cooperation for an integrated biogas governance.

In the Netherlands, biogas development is demonstrating how the interactions can occur under non-linearity and the influence of external regime dynamics. Non-linearity and changes in biogas programme expectations are related to both internal learning processes and external developments (Geels & Raven, 2006). In Indonesia, BIRU could be an external regime from the non-state actors. From 2010, BIRU has proved that they can lead the coordination process for cross-sectoral biogas programmes, although they were limited by power, authority and financial resources. It should be mentioned that the government as a powerful actor must support the coordination effort.

Indonesia should learn from the fragmentation of biogas programs, to reflect on biogas-related policy and governance. This research finding implies greater fragmentation in relation to environmental and climate policy and governance in Indonesia; either cross-sectors from the energy sector, climate change mitigation and adaptation, conservation, zero waste farming, village development, or at the administrative level from local to national. Additionally, coordination is required of those policies and its related bodies to establish an integrated strategy for biogas governance. India, China, and other middle-income countries also experienced fragmentation in their biogas and environmental policy and governance (Bhattacharyya, 2012). These countries used to have a highly fragmented structure in the nature of their policy and governance (Blair, 2000). Regulation has been extensively used as their main policy instrument in environmental governance. Their environmental law, regulation, and governance have evolved over nearly four decades. Thus, this evolution provided lessons for those countries, in

which there was shifting regulatory architectures and explains what has worked and why and it considers the changing nature of the environmental challenge itself (Gunningham, 2009). Indonesia needs to identify which particular architectures are most suited to deal with the nature of biogas and its dissemination barriers.

Alternatively, Indonesia can also build on the integrated governance strategy based on the existing practices. The promotion of bio-slurry from biogas shows cognitive rules and expectations that is guided by technical search and development activities via different biogas programs. This development is caused by interactions between learning processes, network building, and expectations among different actors (Geels & Raven, 2006). It implies that coordination and cooperation among actors are growing by means of the learning process interaction.

Causality to policy output

Some cooperation has been implemented in the biogas regime in Indonesia, in the direction of an integrated biogas governance. Cooperative fragmentation in the biogas regime materialized at the same time as the increase in the dissemination of biodigesters. It occurred in Indonesia for about two years, although when the fragmentation was reduced, the number of disseminations declined (See Section 5.2.1). The question is whether this increase and decrease in output are really caused by the cooperative fragmentation, or was it just a coincidence? China, as a leading country in biogas governance, has experience of that causality. In this country, the transformation of biogas governance developed from fragmented to integrated, which has implications for output effectiveness of biogas policy.

The development of household biogas in rural China involved various policy instruments and governance arrangements, such as directive and guiding policies, economic inspiring policies, research policies, market policies, besides other constructive policies. Every policy was gradually issued by the government. In addition, the National People's Congress also enacted five relevant laws: The Agricultural Law, Renewable Energy Law, Animal Husbandry Law, Energy Conservation Law and the Act on the Development of Circular Economy. Relational rules and regulations in different sectors and at levels were also formed in response to the national policies and laws, whilst the technology standard within projects was also established (Feng, Guo, Yang, Qin, & Song, 2012). These policies were made to boost biogas development in China. Feng et al. (2012), found that a series of constructive policies were gradually issued and proposed from the viewpoint of long-term effective development systems related to the bioenergy industries in China (Peidong et al., 2009). The series of policies were based on an eco-household project that was incorporated into the national bond project. This project was one of the principal tasks of the Chinese government (He, Bluemling, Mol, Zhang, & Lu, 2013) and it was combined with policies on renewable energy development that were issued in 1995 and later with regard to policy on climate (Zing, Ding, Pan, Wang, & Gregg, 2008).

The series of policies involved cooperation among multiple government bodies. Moreover, they contributed to numerous aspects in the development of the biogas sector, such as strengthening strategy research by the National Development and Reform Committee in 2006, enhancing scientific research input by the Financial and Economic Committee and Construction in 2006, continuing technology innovation by the Agricultural Ministry, establishing product quality standards, improving industrial standard systems, opening markets and accelerating commercialization. The coordination among policy actors resulted in its integration in a biogas national plan that was mainstreamed to local government plans (Feng et al., 2012). This cooperative fragmentation produced significant effects in which biogas in rural households in China was growing steadily. The number of household biogas digesters and biogas annual output was double in 2010, compared to 2005. Additionally, the financial incentive increased from 47 million dollars in 2002 to 760 million dollars in 2011 (Feng et al., 2012). China shows that cooperative fragmentation could result in significant policy output. To date, biogas

development has been one of the countermeasures in China's economic agenda (Feng et al., 2012). China is even considering adding national policy support in the fields of scientific research, technological development and the biogas use model (Feng et al., 2012).

China has succeeded in integrating multiple policies to increase the output of biogas development. This integration results from the collaboration between The National People's Congress and the ministries (Feng et al., 2012) and reveals that the development is relatively top-down and government-centric. In Indonesia, the broader economic and political context is different, in which biogas projects are struggling to grow, as leading policies do not prioritize biogas and the programs are fragmented without sufficient coordination. It indicates that the impact of the biogas program, which is measured by the number of biogas digesters that have been disseminated and training activity about biogas use and maintenance, remains relatively low. Coordination and information exchange among actors can support the improvement of each biogas program. Furthermore, cooperation and collaboration can lead to effective governance architecture being created. Moreover, financial investment is required to create market demand to develop the biogas sector. Particular biogas programs may require lower up-front monetary investment and be easier to implement in the short-term (e.g. optimization and the replication of current biogas digesters via improved awareness and technical capacity, accelerated adoption and better maintenance), while others may be considered in the longer term because they require more time and capital to mature (TRANSrisk, 2017). Cooperation is required to boost financial investment.

6.1.2 Biogas policy instruments

The case of biogas governance in Indonesia can also be analyzed from the perspective of policy instruments. This perspective is an alternative tool to examine the configuration of biogas governance.

It is essential to state that most of the governmental biogas programs in Indonesia are in the form of voluntary policy instruments. Voluntary instruments are the interventions that attempt to change people's behavior by providing persuasive information and/or technology by authorities or stakeholders, such as governments, industry, civil society or partnerships among them (Connelly, Smith, Benson, & Saunders, 2012). The voluntary instrument used to be a precursor to other environmental policy instruments, for instance, economic or market-based approaches and regulations (Ten Brink, 2017).

The economic instrument of environmental policy is an intervention in the market that makes polluters receive additional incentives by reducing polluting activities. Connelly & Smith (2003), argued that modification in the structure of incentives can change the environmental behavior of producers and consumers. This instrument is expected to benefit people and to gain an advantage for the environment (Connelly et al., 2012). In the case study of this research, BIRU program sought to bring this approach to the biogas market by promoting the co-benefits of biodigesters that provide incentives not only to the user as the consumer but also to local entities as construction partner organizations (CPO). However, this approach was blocked to some extent by the voluntary approach of the government biogas programs. The grant provided by the government changed the structure of incentives that BIRU sought to construct. The consumer, therefore, preferred to wait for the biodigester grant from the government, rather than buy a subsidized biodigester from BIRU.

Another policy instrument is a regulation which is the most widely used policy instrument. Enforcement of the regulation is achieved through a specific body. Mandatory regulation is regularly known as the standard 'command and control' approach, such as 'banning' (Connelly et al., 2012). In biogas-related policies in Indonesia, there is neither strict standard nor the banning of other cooking fuels that forces the use of biogas. There is only a voluntary policy instrument through scattered biogas programs. For selected programs, there is a 'voluntary' standard for the installation of the biodigester.

It is termed voluntary standard because there is no enforcement to implement the standard. Arimura et al. (2008), suggested that governments should use command-and-control and voluntary approaches concurrently, as effective policy instruments (Arimura, Hibiki, & Katayama, 2008).

Many studies have argued that policy mixes are needed to face the complexity of environmental problems, to deploy a cost-effective and flexible instrument while stimulating technical change and to involve stakeholders (Ten Brink, 2017). Nonetheless, in the case of biogas in Indonesia, the combination of voluntary and economic instruments does not appear to work well. Additionally, the percentage of the voluntary and economic instrument in biogas programs was almost fifty-fifty, a configuration that was often conflicted (See 4.3.3).

Indonesia needs to find a benchmark for effective biogas policy instruments and governance. Gold (2012), found that in Germany, mutually reinforcing the interaction of formal collaboration among policy instruments, business partnerships and equity participation with relational stakeholders proved to be successful in establishing governance architecture for long-term biogas production and biodigester dissemination. The specific rural societal culture also has an impact on governance design. Furthermore, the local rootedness of relational stakeholders can provide high levels of social capital that helps to facilitate the search for effective solutions that satisfy all actors in biogas programs (Gold, 2012).

6.1.3 Summary: Designing an effective governance architecture

The key contribution of this research is the identification of the dynamics of fragmented governance architecture on the policy of small-medium scale biogas in Indonesia. The result found that the fragmentation is caused by not only internal reasons regarding biogas-related institutions who lack coordination and cooperation but also the external conditions, for instance, the lack of effort by the national government to synergize the scattered programs, due to priority reasons. A further interesting contribution is a connection between fragmentation and policy output. The increase in the number of biodigesters being disseminated in relation to cooperative fragmentation in Indonesia is not a coincidence. Case studies on biogas development in China other countries also demonstrate that cooperative fragmentation in relation to their biogas governance architecture succeeds in boosting biodigester dissemination in these countries. This example provides a benchmark option for the future of policy and governance on biodigester dissemination in Indonesia.

6.2 Theory reflection

The integrated analysis of fragmentation, polycentric governance, and policy effectiveness as a conceptual framework has allowed us to better understand the perspective of multiple actors representing different sectors and interests in biogas governance and the wider context of environmental-energy governance. This section discusses the use of theoretical and conceptual frameworks in this research by relying on other literature concerning related theories. Section 6.2.1 questions the causality of fragmentation with policy effectiveness, whilst Section 6.2.2 is a critical reflection regarding the regime complex of fragmentation and polycentric governance. Subsequently, Section 6.2.3 is a summary of theoretical reflection.

6.2.1 Fragmentation and regime effectiveness

This research contributes to the debate on the output of fragmentation as a regime complex. This topic is connected to the output effectiveness of policy and program within a regime, that is discussed in this section. In this research, the distribution of power and coordination are used as the indicators of the regime complex of fragmented biogas governance. As the subset of consequences from the regime, the indicators of biodigester dissemination number and transfer of knowledge are utilized to measure

regime effectiveness. Then, how the distribution of power and coordination affect the dissemination number and knowledge transfer in biogas programs?

The fragmentation is indicated by the existence of interventions (policies or programs) with respect to the issue area by different institutions that are hardly related and has different, unconnected decision-making procedures. In cooperative fragmentation, these interventions are loosely connected or integrated (Biermann et al., 2009). Cooperative fragmentation as a polycentric system has gained international attention as a potential solution to govern environmental problems; nonetheless, there is still little knowledge related to the effectiveness of their output and outcomes (Ahlström & Cornell, 2018; Aligica & Tarko, 2012). In the case of biogas in Indonesia, the output effectiveness of biogas regime is shaped and constrained by competition or cooperation processes in line with the agency and power dynamics among the institutions (TRANSrisk, 2017).

The study of regime effectiveness is distinguished by the perspective: regimes are assessed in terms of the extent of their performance or achievement of their common objective. The idea of effectiveness implies the notion of regimes as potential *tools*, where their usefulness in carrying out a task can be evaluated. In adopting this perspective, evaluation of regime effectiveness concentrates on a *subset* of consequences; those that are relevant to the function assigned to the regime. Other consequences could be side effects that have a direct or indirect relationship to the regime task (Underdal, 2004).

The distribution of power (within the regime) incorporates differences in personnel capacity and incentives in each program or institution, to maximize the quality of the program or policy. The program with higher management capacity and stronger incentives for the target group can increase the quality of the program to produce greater output, as a subset of consequence (Laing, Rivkin, Schiman, & Ward, 2016). Distributed power also allows a different institution to test different schemes and mechanisms (of product dissemination), and to find effective monitoring and evaluation strategy (M&E). The institutions are allowed to manage the objectives, detailed process approach, budgeting and schemes that are used in program implementation, knowledge transfer and M&E (Vedung, 2017). Experiencing various schemes and M&E methods provides the opportunity for the institutions to find an effective mechanism that can result in a new strategy for their program to increase output effectiveness. Subsequently, coordination is required among the institutions to exchange that information, to result in optimum collective output within the regime.

Information exchange is expected to inspire the institutions to reform their planning and practices. Furthermore, it could lead to collaboration and partnership between the program or the institutions (Galaz, Crona, Österblom, Olsson, & Folke, 2012). There is a subset of consequences of such a partnership which falls short of addressing the nuanced incentive-effort-output linkages. The linkages arise when multiple institutions must cooperate and coordinate to achieve the policy objectives. Multiple institutions can work together to deliver proper services to the user. The choice of formal incentives and relational governance mechanisms depends on the degree of interdependence between the various tasks as well as the observability and verifiability of output. With respect to cooperation, an institution must not only put the effort into a "primary" task that they are responsible for but also cooperate by "helping" other institutions to perform their primary tasks (Bapna et al., 2010). This cooperation is required so that the distribution of power in the governance system is not left under the uncertainty of decision-making. It also aims to avoid tensions between different authorities (Laing et al., 2016).

Coordination and cooperation have become popular in support of partnership arrangements. Partnerships as an element within governance fit within the network society. However, the idea of partnership requires the reorganization of policy-making processes and to adjust existing institutional structures. New governance schemes must comply with the existing procedures where they are embedded. Government bodies especially are not prepared to adjust to changes in governance

arrangements. Policymaking in government tends to be based on self-referential organizational decisions, rather than on joint inter-organizational policy making (Teisman & Klijn, 2002). This issue is a challenge for the feasibility of intended cooperative governance processes within government. Thus, it becomes a challenge to the effort to increase output effectiveness as well.

A further barrier to cooperation is the perception of effective governance (Berdej & Armitage, 2016). For instance, different actors related to technology would have different perspectives and framings on how energy governance should look like and how to achieve it. In biogas in Indonesia, BIRU wanted to train as many local stakeholders as possible to boost the dissemination of biodigesters. On the contrary, PT SWEN wanted to monopolize the techno-scientific information concerning biogas, to rule the biogas business. This singular perception influences other actors to agree with their own stand. On this basis, an approach should be developed to find effective cooperation within the complex interactions and myriad of actors involved in shaping and constraining design, deployment, and dissemination in fragmented biogas programs. This approach is required to determine an integrated strategy within the regime.

In assessing regime effectiveness, the costs incurred in establishing and operating the regime are regularly left out of the evaluation. Effectiveness hence does not become the net achievement, but a matter of gross. Therefore, effectiveness should not be confused with efficiency. It is also important to keep in mind that regimes are typically designed to promote the interests of the dominant members. If the interests are significantly different from the minority members, it may create a serious problem or conflict within the regime. In other words, effectiveness does not imply fairness (Underdal, 2004).

Underdal's thesis works for the cooperation of large institutions within the regime. Moreover, cooperation without corresponding increases in output is not likely to be cost-effective (Torres & Paul, 2006). In biogas in Indonesia, it may be another reason that the Ministry of Agriculture (MA) does not combine their biogas program with programs from the Ministry of Energy and Mineral Resources and BIRU. The cost is not economically justifiable for them as large institutions (Torres & Paul, 2006).

However, the coordination and cooperation of small institutions within the fragmented regime might generate cost efficiencies that increase policy output, depending on the concurrent expansion of the network (Torres & Paul, 2006). This case happened in the cooperative network within the BIRU program and the local governments in Indonesia. But then, the reason for being cost-effective may only work for business entities and it may be different for the nature of government bodies. Therefore, the consequence of output efficiency as the advantage of the cooperative fragmented regime is still under questioned or contextual.

In the wider discussion on the relationship of regime complexes with (state) policymaking perspectives, regime complexes become denser over time while governmental policymaking tends to become more coherent. Globally, interactions between regime complexes and national policymaking are twofold. Coherence among policies generates negotiation and mandates requesting for connections between and within regime complex. Conversely, regime-complex density creates more cohesive audiences, which increase incentives for national policy coherence. This co-adjustments model brings states into the discussion concerning institutional interactions and critically questions the desirability and feasibility of recent calls for joined-up government and whole-of-government approaches (Morin & Orsini, 2013).

6.2.2 (Pathways to) polycentric governance

In the theoretical framework chapter, the fragmentation was explained together with the framework of polycentric governance. Both are seen as a form of regime complex. Both regimes require formal coordination between different arrangements from distributed power within them, to integrate their work relating to common objectives. The state regime needs to have better coordination with non-state

institutions in order to minimize conflict, particularly with regard to business and NGOs (Biermann et al., 2009). The interaction between actors within the regime can stimulate work on how to address conflicted institutional fragmentation (Zelli & Van Asselt, 2013). Regime complexity and institutional fragmentation used to be referred to in the case of global governance (A. Jordan, Huitema, van Asselt, & Forster, 2018). This research applied that theory to the case of national governance. The result is that polycentric governance was found to be a one step forward regime compared to cooperative fragmentation. This finding is considered as a theoretical innovation (Figure 9). Polycentric governance might be referred to synergized fragmentation.

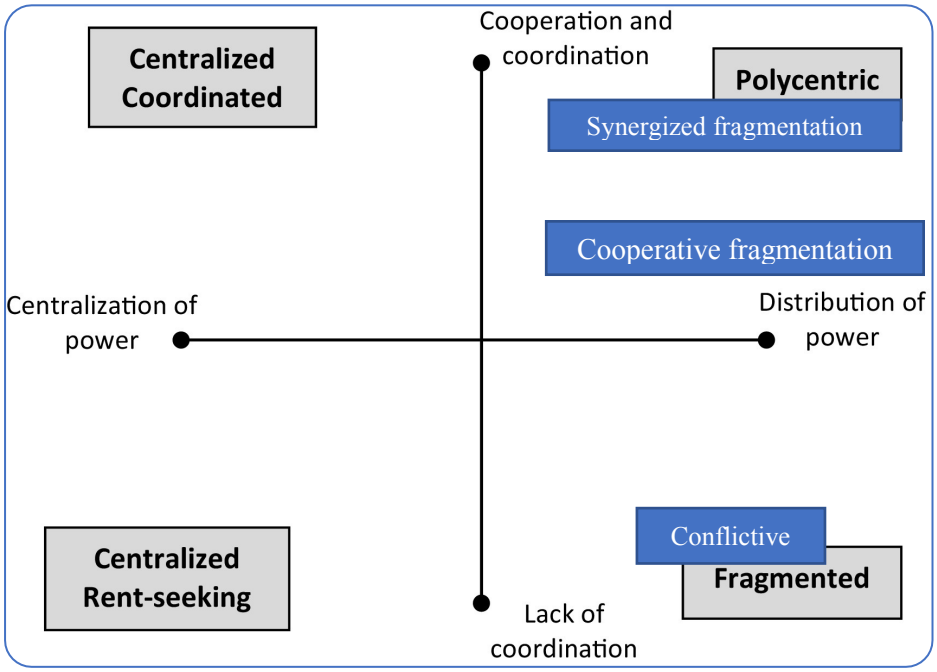

Figure 9 New configuration within the governance model

As a regime complex, cooperative fragmentation utilized the indicator of inclusiveness for power distribution. This indicator relates to the way of creating legitimacy by achieving an equal distribution of burdens and benefits for each institution (Widerberg & Pattberg, 2015). This equity could be defined as a proper representation of key stakeholders during the decision-making process within the regime or governance architecture. Inclusiveness is sub-divided into two categories: scope and quality. Scope examines who is participating in the decision-making process and whether the affected constituency is represented. Quality is determined by the process of decision-making procedures (Widerberg & Pattberg, 2015). Meanwhile, in polycentric governance, the power distribution goes beyond the decision-making procedures. Polycentric regimes combine the distribution of power with relation to resources of authority, finance, and knowledge, and effective coordination among various centers (lead institution) and across spatial levels and sectors via integrated platforms. The modular structure characterizing polycentric systems increases resilience and the capacity for dealing with challenges and barriers (Pahl-Wostl & Knieper, 2014).

While cooperative fragmentation only ensures equal participation of the institutions in decision-making, polycentric governance utilizes a centralized coordination setting in decision-making that has a certain degree of autonomy to support experimentation and learning (Galaz et al., 2012). Therefore, polycentric regimes are assumed to have higher performance, with respect to the adaptive capacity of the institution in dealing with emerging environmental problems, such as the use of energy (Folke, Hahn, Olsson, & Norberg, 2005; Ostrom, 2001, 2010).

In cooperative fragmentation, specific actors remain outside the main governance architecture but maintain coordination and cooperation. Most initiatives acknowledge the process of the main governance architecture, but many do not provide a coordination mechanism that could ensure mutual compatibility (Biermann et al., 2009). Therefore, cooperative fragmentation does not have very effective coordination such as that observed in polycentric governance. Without effective coordination, the distribution of power overlaps responsibilities in different decision-making centers. This situation creates contradicting actions with loss of effectiveness and efficiency (Lieberman, 2011). In large river basins in Europe, Africa, and Asia, the lack of effective cooperation across sectoral and administrative boundaries was identified as an important barrier for climate change adaptation (Krysanova et al., 2010).

In polycentric governance, coherence is an effective cooperation. An example is from the field of global renewable energy that had a fragmented landscape consisting of the International Energy Agency (IEA), the UNFCCC, the CSD, UN-Energy, SE4ALL, and several global partnerships, initiatives, and forums. Nevertheless, they developed effective cooperation and established IRENA as an institutional home that creates a hub where the scattered initiatives can gather, exchange information and generate synergies (Widerberg & Pattberg, 2015).

A model of polycentric governance (Figure 10) is described through four processes; a) information sharing among programs/actors through an information exchange platform, b) collaborative activities as a result of the exchange platform, c) emerging formal partnerships among programs, d) adjusting the structure of a partnership when conflict appears (Galaz et al., 2012). Cooperative fragmentation includes the two processes in polycentric governance; specifically, information sharing and collaborative activities.

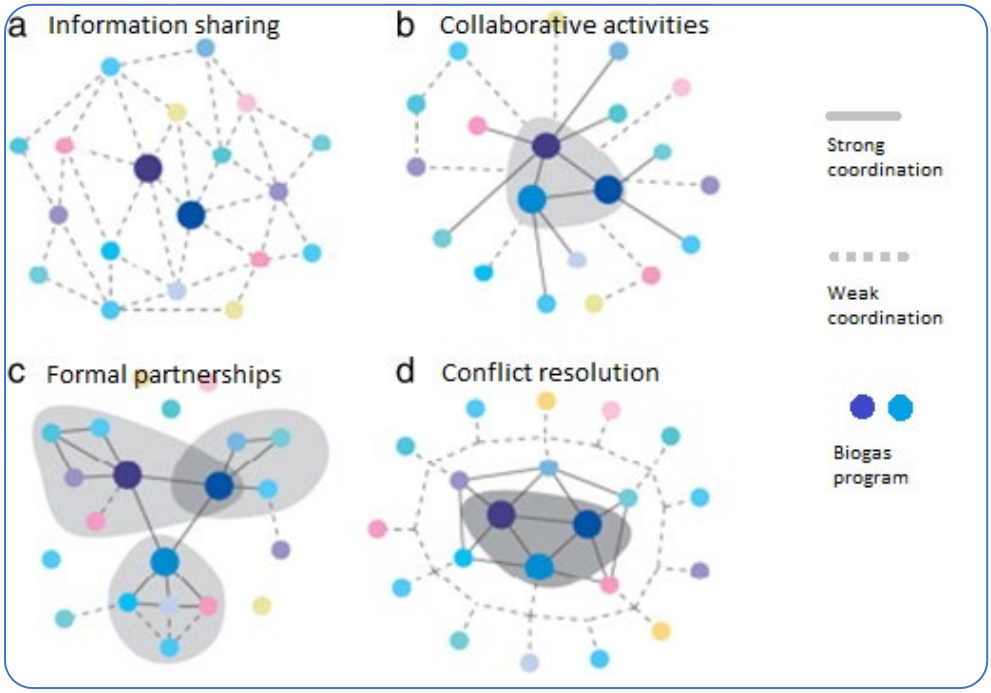

Figure 10: Pathways to polycentric governance (Galaz et al., 2012)

In the case of Indonesian biogas governance, the change in the architecture in 2017 has altered the distribution of power regarding biogas programs, when coordination among biogas programs was actually improving. The change in power distribution stopped the way forward from cooperative fragmentation to polycentric governance. Biogas governance in Indonesia has reached three stages of information sharing, collaborative activities, and formal partnerships. However, conflict about data and funding appears to be resolved in a different way, applying the logic of the polycentric model. The

national government resolved it with the centralization of all power resources. If the government chooses to have a centralized coordination setting, then it may change the architecture relating to effective polycentric governance (Zelli & Van Asselt, 2013).

The choice of centralization as conflict resolution by the Indonesian government might be caused by the misinterpretation of the logic of coordination. The national government chose the shortcut to integrate related programs into the project of one data one policy, avoiding the option for the centralized coordination setting. The institutional ego might be the reason for that government decision. Institutional ego is the selfish attitude of an institution that avoids cooperation. The institutions that support sectoral (ego) approaches, did not participate in common agreements on governance architecture (Biermann et al., 2009). Institutional ego created competition among institutions, instead of coordination. Additionally, a combination of fragmentation and (economic) competition might result in the general decline of regime output, the so-called 'race to the bottom', away from polycentric governance (Biermann et al., 2009).

Fragmentation and polycentric governance as a regime complex are types of governance architecture. The architecture of polycentric governance has been developed with various models and indicators. In the domain of climate change, a more polycentric pattern is produced from the dynamic architecture of climate governance. Particular analysts believe that the new structure will fill gaps in the existing regime, although this assumption about their diffusion and performance is untested. Polycentric governance offers new opportunities for governance architecture, nevertheless, the effectiveness of the model is not well founded yet (A. J. Jordan et al., 2015). This research has contributed to discussing the relationship between cooperative fragmentation, polycentric governance, and its effectiveness. Polycentric governance can be one step further from cooperative fragmentation. For a specific domain such as biogas or bioenergy, it can be done by having a centralized coordination setting led by a particular institution. Furthermore, there is an emerging pattern that the shift from fragmentation to polycentric governance could increase the effectiveness of policy output (Heikkila, Villamayor-Tomas, & Garrick, 2018).

Alternatively, cooperative fragmentation and polycentric governance can also be combined with the approach of socio-institutional factors influencing technological dissemination. Socio-institutional change is necessary to pursue low carbon development pathways, especially concerning clean energy transition for cooking fuel (TRANSrisk, 2017). In addition, polycentric governance is exploring agency and power to identify potential 'agents of change' favoring socio-technical transition. Biodigester dissemination is argued as a transition pathway for climate action and clean energy for cooking (TRANSrisk, 2017). The idea of transition pathways draws upon a different type of conceptual model, primarily the multi-level perspective or MLP. MLP identifies key implementation risks (barriers) and opportunities, besides potential agents of change both at the 'niche' level and within the incumbent 'regime' (Genus & Coles, 2008). Additionally, polycentric governance identifies dissemination barriers and opportunities for supporting coordination and cooperation among actors to collaborate across levels and regimes. Multiple actors within fragmented biogas governance require the coordination for a socio-technical transition. The coordination and steering of many actors and resources can enact system-level change and trigger emergent features of transformation processes. Likewise, it involves active coordination by technological actors as the agency on the part of architecture networks (A. Smith et al., 2005). Polycentric governance is addressing the degree of intentionality and shares the goal to support the socio-technical transition to low-carbon development pathways.

6.2.4 Summary

This research examined the relationship between the theories of fragmentation and its regime effectiveness. The result found that coordination among actors that has a relatively equal distribution of power and information exchange platform can trigger innovation that influences the output effectiveness of their programs. This finding hence relates to another interesting link to polycentric governance. Polycentric governance is found as an advanced regime that resulted from cooperative fragmentation. By having a centralized coordination setting in polycentric governance, it can trigger the opportunity to increase output effectiveness even more.

However, there are two limitations pertaining to the theoretical framework of this research; 1. The detailed indicator in the theoretical framework, 2. Links to technology development and market function, as part of a wider indicator in biogas governance. The limitation in the theoretical framework has the consequence on the result of the research. This research limited attention to detail in the indicators in the framework, due to the limitation of resources (time and cost) to explore it in the field. For example, power dynamics relate to legitimacy that has a 'structural' component whereby decisions and options are shaped by institutional factors. From this perspective, the institutional setting can significantly influence the construction of guiding dominant visions (e.g. discourses, narratives or storylines) and the deployment of resources to fulfill them (A. Smith et al., 2005; TRANSrisk, 2017). The framework of this research did not analyze the legitimacy as a detail explanation in relation to power distribution.

Limited resources and time-frame of this research also caused the exclusion of specific analysis regarding technology development and market function or the first-hand experience of actors engaged in the biogas system, in the framework of the research. This topic primarily includes the experiences of those actors within the supply chain (e.g. technology installers, users), and of service providers supporting the market chain function (e.g. NGOs and researchers involved in pilot experimentation), besides the cost barriers. The inclusion of this part should provide a more comprehensive overview of the performance of fragmented biogas governance architecture.

6.3 Methodological reflection

This section highlights a few reflections and limitations of the method used in this research. Sub-section 6.3.1 reflects on the use of the qualitative method. Moreover, sub-section 6.3.2 recognized the limitation of the method.

6.3.1 Reflexivity and external validity

This research utilized a qualitative method from interviews with purposive and snowball sampling obtained from biogas-related stakeholders. The use of this method brought the element of reflexivity to the study. The questionnaire included a final question asking the opinion of the stakeholders about the fragmentation of biogas programs. This question was included to offer stakeholders the opportunity to critically reflect. In no way did it mean to influence the result. Particular stakeholders found this question interesting, seeing as they did not comprehend the fragmented situation in biogas policy and governance, due to their lack of knowledge about other stakeholders. Some others were already aware of the fragmented biogas programs, but they choose to accept the situation or disregard the coordination problem within it. Overall, the interviews were able to make the stakeholders aware of the problem of lacking coordination in the fragmentation and the need for cooperation as the solution. This method provided a participatory element that gave new information to the actors during the interview.

There is the opportunity to advance the research method to the next level. After transferring knowledge by way of the interview, the focus group discussion can be utilized to discuss further the possibility to develop coordination among (biogas) programs and policy or even to design new

governance architecture. This method can also be tested in other countries with emerging biogas markets, such as India, Sri Lanka, Nepal, Vietnam, Brazil, and Tanzania.

Regarding external validity, the procedural variables are not only limited to four selected institutions in the case study, it can be applied to several other ministries who also have other biogas programs. The selection of the case study does not affect the representation of the generalizability of the study. Consequently, the research can be generalized to the wider population of biogas-related actors. The results of the study may also be generalized to other topics and stakeholders on environmental policy and governance, with various adjustments regarding the context.

6.3.2 Limitations

Limitations concerning the method are connected to topics related to data quality, reliability, and internal validity. This research ensured reliability by using consistent estimates or assumptions of the same phenomenon or indicators in each biogas program or institution. There may be a limitation in data quality because there are different methods and availability in data collection regarding dissemination units and training provided by each biogas program from different institutions. For example, BIRU and the MEMR utilized a different approach in their data collection and M&E of biogas dissemination. Besides, data on dissemination location was not available from all biogas programs. This limitation is exacerbated by the reliability of data available from the government bodies. Certain government bodies did not use proper methods and tools in gathering the data.

In terms of validity, the internal validity of this research is limited to some extent. It is because the causal relationship between the indicators of fragmentation and policy output as the subject variables in the study is still debatable in certain literature. The actors are influencing each other; the window of opportunity in fragmentation might be caused by pressure from their own interest. More analysis relating to what extent this interest affects the fragmentation was not elaborated upon.

The following challenge is related to the construct validity of this research. Occasionally, a researcher may have the challenge to develop a sufficiently operational set of measures and it becomes the subjective judgment for collecting the data (Yin, 2009). It may occur in this research because the data was collected and interpreted by a single observer, without a second observer. Moreover, in the data collection, natural events could be influenced because the object knows that they are being studied. Reflexivity may possibly occur when the interviewee provides (relative) an answer based on the preference of the interviewer.

Chapter 7: Conclusion and recommendation

This chapter recaps the problem background, objectives, framework, method, and answers the research questions of this study. Then, some recommendations are provided based on the findings and the discussion.

The problem background of this research is that there is fragmentation within small-medium scale biogas programs in Indonesia that led to conflict among the programs. This incoherence is caused by the exclusiveness of particular institutional actors, which led to the ineffectiveness of the programs' output. This fragmentation is also a problem for international policy because it causes double counting for greenhouse gasses emission reduction. The fragmented governance architecture, with weak institutions, makes policies are vulnerable to ineffectiveness that hinders transition pathways for low carbon development through biogas sector. Until 2015, the total number of biogas digesters only accounts for 1.24 percent of households in Indonesia and biogas is hence much less common than other cooking fuels. There are some barriers and factors constraining biogas digester dissemination, which are; bureaucratic process, the time-consuming process of feedstock, social acceptance, different priority, monitoring practices, and poor technological maintenance. These multiple barriers to dissemination are exacerbated by the problem of the fragmented governance structure of the biogas programs. This problem is related to the absence of coordination among those programs that limits cooperation among them. All biogas programs come with different approaches and several types of digesters. It reflects that the biogas policy architecture in Indonesia is fragmented and not integrated into a single framework. This research aims to explore the landscape of biogas governance in Indonesia, its fragmentation, and its effectiveness for policy delivery.

The conceptual framework of this research combines theories of fragmentation and polycentric governance as a framework that features specific component/aspects like coordination and the distribution of power. This research utilizes both theories to link the indicators within those theories. For methodology, this research utilized qualitative data analysis. This method is an interpretative research which involved multiple forms of qualitative data. The toolkit for guiding implementation of the integrated method and conceptual approach consists of interviews, document reviews, and series of analysis in relation to the conceptual framework.

7.1 Conclusion

This section answers the research questions of this research based on key findings in chapter four and five. The sub-section 7.1.1 answers the first sub-research question, and the sub-section 7.1.2 compiles the answers for the second and third sub-research question, as well as conclude the answer for the main research question. In addition, the sub-section 7.1.3 provides a conclusion beyond the findings of this research, from the discussion chapter.

7.1.1 Characteristics of biogas programs and barriers biodigester dissemination

Biogas programs in Indonesia are found scattered in NGO and different ministries, such as the Ministry of Agriculture (MA), the Ministry of Energy and Mineral Resources (MEMR), and the Ministry of Environment and Forestry (MEF). Each ministry has different motivation to have the program. In the MA, the motivation is to manage cattle manures for compost and biogas. For the MEMR, biogas program aims to reduce the cost of subsidy for kerosene and LPG and to achieve energy mix target. In the MEF, the biogas program helps them for forest conservation, forest community development, and emission reduction. Different motivations and problem background show that the biogas programs in those ministries relate to different policies such as energy mix target, NAMA, agriculture waste management, and forest conservation. It shows that the fragmentation of biogas-related policy is wider

than energy and climate change policy. The fragmentation of biogas programs is even more scattered when the scope of this research is expanded to other ministries and large-scale biogas programs.

Almost all governmental biogas programs relatively have the same characteristics, which are scattered in different directorates or sub-institution within the ministry, using the grant approach, cooperate with local government and vendor, and do not have proper training and M&E. There is no effective coordination among these governmental programs. Low degree of coordination results in lack of cooperation to achieve the bigger target for renewable energy and emission reduction. Meanwhile, the NGO program-BIRU utilizes semi-commercial approach; collaborates with multiple government bodies, construction partner organizations, cooperatives, and private sectors (companies and banks); and has standardized training and after sale services. The fragmentation triggers innovation in different biogas programs, especially on BIRU.

The fragmented situation on biogas programs affected the capability of each program to tackle barriers in biogas digester dissemination. There are multiple barriers along the supply chain process of biodigester dissemination, from production to consumption. These barriers are also related to socio-cultural issues and policy problems. All barriers relate to the governance aspect of biogas programs; lack of knowledge on the users is caused by program management issue in which planning and implementation on training and M&E are insufficient; lack of coordination among biogas programs to exchange information reduces the opportunity to conduct best practices on- biodigester installation, creating demand from the consumer, and having effective program management and approach; lack of demand is caused by the full subsidy approach by the government. These barriers are relevant to most of the biogas programs.

To tackle those barriers, fragmented biogas governance requires coordination and cooperation among programs to result in more effective output. To trigger the coordination, five strategic factors are required; putting biogas as top commitment or priority on development agenda, creating mutual understanding among the institutions, building relationship among actors for effective decision-making, and establishing information exchange platform between organizations.

7.1.2 Fragmentation and the implication to output effectiveness

From 2007 to 2017, there has been the dynamics of power distribution and cooperation within biogas governance architecture in Indonesia. The dynamics of power distribution are based on these following indicators; distribution of institutionalized functions-responsibilities-authority-and finance across programs; the level of decentralization in accordance with the available personnel capability for knowledge; and the degree of partnership on planning and implementation. While the indicators for cooperation is; the existence of a single piece of a policy framework; formal provisions to support coordination and cooperation among organizations across administrative levels and sectors; clear allocation of tasks and functions; and involvement of local institutions in the creation of biogas-related institutions/programs. These indicators define the configuration of the regime, whether it is conflictive or cooperative. The absence of coordination within the distributed power triggers conflicted fragmentation. This situation happened in the biogas governance architecture in 2010-2013. Coordination and cooperation are required to harmonize the distributed power within the architecture. The cooperation started to develop in 2014.

Dynamics in power distribution and cooperation within the architecture form periodical shifts of configuration within the regime, from administrative fragmentation in 2007-2009, conflictive fragmentation in 2010-2013, cooperative fragmentation in 2014-2016 with increasing degree of cooperation within this period, and reduced fragmentation after 2017. This shift had implication to affect the output of biogas programs. The number of biodigester dissemination and the activity of knowledge transfer increased from 2007 to 2016.

In 2007-2009, the phenomenon of administrative fragmentation happened due to different government bodies have the same type of biogas programs which is not integrated. After 2009, a new program called BIRU emerged from Hivos. From 2010 to 2013, BIRU had installed about 11K digesters and the MEMR disseminated 4K digester. This contribution increased the total number of biodigester dissemination to be 16 K units. The establishment of BIRU and the emergence of Directorate of Renewable Energy in the MEMR increased the degree of fragmentation to biogas programs. BIRU derived more donors and the MEMR gained more budget allocation for biogas programs, it caused more money being available for their collective biogas dissemination. This power distribution triggered speed of program implementation that resulted in the rise of the number of dissemination. Yet, there was a conflict between BIRU with PT SWEN as a vendor to biogas programs from the MA.

In 2014-2016, coordination of BIRU with more government bodies had effects on output of biogas programs. This cooperative fragmentation increased the number of biodigester dissemination more than doubled in three years, from 16K in 2013, to 37K in 2016. The cooperation also affected the training of users in biogas programs. There is more standardized training implemented in biogas programs. The standards were made by Hivos and YRE through BIRU program that trained many construction partner organization (CPOs) to deliver knowledge to biogas users. These CPOs also applied the same standards when they worked with other biogas programs from the ministries and local governments.

The cooperation between BIRU, the MEMR, and other institutions contributed to increasing number of biodigester dissemination. BIRU's strategy to train CPOs also created more expertise on biogas builders. Cooperative fragmentation increased the number of biodigester dissemination and knowledge transfer about biogas. This finding shows how the cooperative fragmentation of biogas programs in Indonesia affect the dissemination of biodigester and knowledge transfer.

In 2017, a new centralization policy from the government reduced the power distribution within the biogas governance architecture. This change contributed to the decline in the number of biodigester dissemination. The different degree of fragmentation of biogas programs in Indonesia has a different effect on the number of biodigester dissemination and its knowledge transfer among the stakeholders.

In addition, the centralization in 2017 also stopped the transformation of biogas governance architecture to move forward to polycentric governance. Biogas governance in Indonesia has reached three stages of polycentric governance which are; making a platform for information sharing, creating collaborative activities and establish formal partnerships. However, conflict about data and funding appears to be resolved by the government in a different way, applying the logic of the polycentric model. The national government resolved it with the centralization of all power resources. If the government chooses to have a centralized coordination setting, then it may change the architecture relating to effective polycentric governance. Polycentric governance is required to tackle cross-sectoral dissemination barriers of the biodigester. Biogas governance requires multi-level and multi sectors collaboration from energy, agriculture, environment, and village development, to bring better output, outcome, and the environmental impact of biogas programs.

7.1.3 Regime effectiveness

This research is a study of regime *effectiveness* that is distinguished by the *perspective*: regimes are assessed in terms of the extent of their performance or achievement to their objective. The idea of effectiveness implies the notion of regimes as potential *tools*, where their usefulness in carrying out a task can be evaluated. In adopting this perspective, evaluation of regime effectiveness concentrates on a *subset* of consequences; those that are relevant to the function assigned to the regime. In this research, the distribution of power and effective coordination are used as the indicators of the regime complex in

fragmented biogas governance. As the subset of consequences, the indicators of dissemination number and transfer of knowledge are utilized to measure regime effectiveness.

This research applied the approach of regime effectiveness to the case of national biogas governance. The result is that polycentric governance was found as one step forward regime, compared to cooperative fragmentation. This research has contributed to discussing the relationship between cooperative fragmentation, polycentric governance, and its output effectiveness. For the specific domain such as biogas or bioenergy, polycentric governance can utilize a centralized coordination setting led by a particular institution. There is an emerging pattern that the shift from fragmentation to polycentric governance could increase the effectiveness of output within the regime.

7.2 Recommendation

As of implications of abovementioned conclusion, this research provides two types of recommendations; 1. Practical policy recommendation to increase the performance of bioenergy policy and governance, and 2. Further research to strengthen the implementation of the policy recommendation, and to explore the innovation on the field of environmental-energy policy and governance.

7.2.1 Policy recommendation

This policy recommendation is categorized into two types, which are short term and long term. These recommendations aim to increase the output of biogas governance, particularly in Indonesia. Here are some following suggestions for the short term;

- To enforce regulation on the use of biogas through reducing the subsidy for LPG, particularly on farming regions that have potential to generate biogas
- To create a policy framework of an integrated biogas national plan that combines different targets from the energy mix, NAMA, BIRU, and other related policies.
- To return the distribution of power in biogas governance architecture, back to the MA, the MEF, and other related ministries, to implement biogas programs
- To formulate clear allocation of tasks and functions for different institutions in achieving the common target and plan for biogas programs

After the short-term recommendations applied, the stakeholders are expected to implement these long-term recommendations, as follow;

- To increase the degree of partnership on the planning and implementation among the program, by using integrated topics like climate action, renewable energy, and rural development
- To have (in)formal provisions to support coordination and cooperation among organizations across administrative levels and sectors
- To involve local institutions more actively in the creation of biogas-related institutions/programs.
- To distribute institutionalized functions, responsibilities, authority, and finance across programs
- To adjust the level of decentralization in accordance with the available personnel capability in term of knowledge

These recommendations are also suitable to be implemented beyond the case of biogas governance and outside Indonesia. Those recommendations have broader applications in the field of environment and renewable energy policy and governance.

7.2.2 Further research

To implement some of those recommendations, particularly for the long-term recommendation, more research is required in various topics. Beyond Indonesia, the comparative study with biogas national plan in other countries, such as China is needed to learn about the detailed process of cooperative fragmentation in the country. Alternatively, the lesson learned from biogas governance in the Netherlands and Germany could also be a useful benchmark of biogas governance. These countries have experiences in process of increasing the effectiveness of decentralization regime that can be utilized to design an effective governance architecture.

Inside the country, further research about coordination between different policy instruments related to biogas is needed. An effective governance architecture must have the ability to manage different biogas policy instruments within the regime complex. Instead of competition, different instruments need to have cooperation, to increase the effectiveness of the program output. The study about the coordination of regulation related to biogas, such as energy and climate policy is required, to find the opportunity to synergize the target, planning, and the implementation of integration of biogas policy plan with environmental-climate action. This topic includes the possibility to have coordination between small-medium scale biogas programs with large-scale biogas from industries, power plant, and landfill.

In the wider picture, the coordination triggers the combination of topics of agency, power and market function. These topics analyze potential 'agents of change' that could support the collaboration among actors and by focusing on key strategies that have the potential to catalyze centralized coordination setting in polycentric governance. Furthermore, the study about the feasibility of implementation of polycentric governance for biogas governance architecture is also needed. Can the nature of the socio-economic and political condition of biogas in Indonesia work for polycentric governance?

One of the conditions to support polycentric governance is the readiness to practice e-governance. The study about the capacity of government and NGO in sharing the common platform such as 'e-governance' is required. To track the progress of various biogas programs, information and communication technologies can make a significant contribution to achieving good governance goals. The 'e-governance' can make governance more efficient and more effective through improving government processes (e-administration), connecting actors; and building external interactions such as between the program providers and the users or consumer (Heeks, 2001). Currently, few governmental biogas programs in Indonesia already starts the e-administration. Yet, the integration among platform is still absent, especially with the non-governmental program. Further research is needed to fulfill this knowledge gap.

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Appendix 1: Specific topic list

Topic list in Table 3 is 'translated' into a specific list to be the guide for the actual questions that were asked for data collection. These topics were applied to each biogas program, but it was adjusted for each specific actor.

Sub-Research questions	Aspects	Topic list
1	Governance arrangements	• General info about the programs, brief history • strategy to operationalize the program or (policy) instruments), • actors (state, market, and civil society) involvement, • interactions between actors, • coordination between the institutions
2: fragmentation	Inclusiveness: distributed power	• Partnership with other programs in planning/project development, • partnership in project implementation
		• Distribution of functions in partnership, • responsibilities/ tasks division (in partnership), • distribution of power across programs, • the institutionalization of distribution/informal structure
		• Position in decentralization/partnership, • available personnel capability, • capability in decentralization
	Coordination and Cooperation	A national biogas-related policy is coordinated/integrated into one single piece of the framework (i.e. national biogas plan)
		• Formal provisions (procedures) to support coordination among organizations across administrative levels (city/regency, province and national) and sectors (energy, agriculture, environment), • result in cooperation
		• Involvement of local governments in the biogas programs, the creation of biogas-related institutions across levels (farmers, local, national), • the effect of the institutions on the local practice
3	Output effectiveness	The number of biogas digesters disseminated
		The amount (and quality) of information provided

Appendix 2: Interview questions

Aspects	Questions
Governance architectures	• Tell me general information about your biogas program • What is its brief history, how it was initiated? • Year of introduction? • What is the motivation/problem background/policy-driven? • What is the strategy to operationalize the program (policy instruments)? • How is the approach to the users? Is it given for free/subsidized/sale? Before and after 2009? • Who are actors (state, market, and civil society) involved in the program? the implementation agencies and funding donors? • How are interactions between actors (within the program)? • How is coordination between the institutions (outside the program)? • Any change/development in the project (strategy, approach, network) (e.g; in the period before and after 2009 due to BIRU)?
Output effectiveness	How many has the number of biogas digesters been disseminated? What are the challenges/supports? Before and after 2009? Future target?
	How is the geographical coverage of the dissemination? Before and after 2009?
	How much actual expenditures (on its subsidies)? What are the challenges/supports? Before and after 2009?
	What is the amount (and quality) of information (workshop and training for users) provided? What are the challenges/supports? Before and after 2009?
Inclusiveness: distributed power	• What is your partnership with other biogas programs in biogas project development *planning*? • What is your partnership with other biogas programs in project *implementation*? • How is the distribution of power across programs?
	• How is the distribution of functions in the partnership? • How is responsibilities/ tasks division (in partnership)? • How is the institutionalization of that distribution? How is Informal structure of partnership/task division? • Who provide techno-scientific information (juknis) for biogas installation and maintenance? • If others, how the task division/coordination works?
	• What is your position in that partnership/decentralization? • What is your available personnel capability? • How the personnel capability matches with your position in partnership/ decentralization?
	Any changes in power distribution (e.g; in the period before and after 2009)?
Cooperation	• Is there a national biogas-related policy that is coordinated/integrated into one single piece of the framework (i.e. national biogas plan)? • What is role of national energy council or Dewan energi nasional? And BIRU? • Your institution role?

	• What is formal provisions (procedures) to support coordination among organizations across administrative levels (city/regency, province and national)? • What is procedure to support coordination among sectors (energy, agriculture, environment, etc)? • What is the result of the coordination? Is there cooperation/collaboration?
	• How is involvement of local governments in the biogas program? • Connection of national biogas program with local/provincial biogas program such as from ditjen to taman nasional? • Is there creation of biogas-related institutions across levels (farmers, local, national)? • What is the effect of those institutions to the biogas dissemination?
	Any changes in coordination/collaboration in the period before and after 2009?
Output effectiveness	What do you know about how many numbers of biogas digesters disseminated from all/other programs?
	The approach and geographical coverage?
	What do you know total expenditures (or subsidies) from all/other programs?
	What do you know about the amount (and quality) of information provided by all/other programs?
Fragmented regime	What do you think about fragmented biogas programs in Indonesia? different motivation/policy-based objective?
	What is your opinion about connecting different biogas programs?
Snowball	Who would you recommend being interviewed further about this topic?
	Any document reports about your biogas programs?

Appendix 3: List of interviews

Date (2018)	Institutions	Time (GMT 7)	People/representatives, position	Location	Citation in text
1-Jun	Su-re.co (research & consulting firm)	2:30 PM	Novelita Mondamina, ex-researcher	Masjid salman ITB, Bandung	(Su-re.co interview, 1 June 2018)
2-Jun	Hivos	10:00 AM	Robert de groot, Coordinator of Green Energy	Pejaten, Jakarta Selatan	(Hivos interview, 2 June 2018)
4-Jun	Directorate of agriculture infrastructure, MA	8:00 AM	Anis Minarwati, SP, M.Sc (Head of department of fertilizer); Sakino (Staff of department of fertilizer)	MA office, Building D 9th floor, Ragunan, South Jakarta	(MA interview, 4 June 2018)
4-Jun	MDP	11:00 AM	Syamsidar Thamrin (Directorate of energy, telecommunication and informatics)	Bappenas office, 4th floor 4, Menteng, Jakarta	(MDP interview, 4 June 2018)
5-Jun	YRE	12 AM	Yudha, Regional coordinator for West Java, Banten, and Lampung	YRE office, Pejaten, South Jakarta	(YRE interview, 5 June 2018)
5-Jun	YRE	10:00 AM	Satya Budi Utama, Director	YRE office, Pejaten, South Jakarta	(YRE interview, 5 June 2018)
6-Jun	Directorate of bioenergy, MEMR	9:00 AM	Tody Ferdica (sub-directorate of partnership and investment), Yunita ariani (Division of program and planning), Fitria yuliani (head of partnership division)	The office of renewable energy directorate of MEMR, 5th floor, Cikini, Jakarta	(MEMR interview, 6 June 2018)
7-Jun	Directorate of natural resources conservation and ecosystem, MEF	9:00 AM	Wiratno, director general	MEF office, Manggala wanabakti building, block 1, 8th floor, Jakarta	(MEF interview, 7 June 2018)
	Directorate of natural resources conservation and ecosystem, MEF	11:00 AM	Bisro (division of conservation)	MEF office, Block 7, 7th floor, Jakarta	(MEF interview, 7 June 2018)
	Renewable energy research center (RERC), MEMR	2:00 PM	Arfi and ikrar, researcher	The office of RERC, Komplek lemigas, Cipulir, Jakarta	(RERC interview, 7 June 2018)

	Directorate general of livestock, MA	4 PM	Tika, head of sub directorate of food process, directorate of process and marketing	MA office, Ragunan, South Jakarta	(MA interview, 7 June 2018)
8-Jun	MA	11 AM	Chaerudin	MA office, Ragunan, South Jakarta	(MA interview, 8 June 2018)
8-Jun	Su-re.co	2:00 PM	Cynthia JI, researcher	Fx Sudirman, Jakarta	(Su-re.co interview, 8 June 2018)
	Yayasan Kontak Indonesia, CPO BIRU	1 PM	Cahya Hendra, division of program, dept of environment	Jl Riau, Bandung	(YK interview, 12 June 2018)
12-Jun	Koperasi Peternak Sapi Bandung Utara (KPSBU), Loan partner organization-BIRU	10 AM	Ramdan, board member	KPSBU office, Lembang, Bandung	(KPSBU interview, 12 June 2018)
	West Java Energy and mineral resources agency (EMRA)	2:00 PM	Tubagus, head of energy department	West Java EMRA office, Bandung	(West Java EMRA interview, 21 June 2018)
21-Jun	Bandung regency agriculture agency	10 AM	Hera hendrawan, head of livestock department	AA office, Soreang	(Bandung regency AA interview, 21 June 2018).
	Ministry of coordinator of maritimes (MM)	10:00 AM	Hendra, deputy of division of natural resources coordination	MM office, jl thamrin no 8. 8th floor, Jakarta	(MM interview, 25 June 2018)
	Directorate of climate change, MEF	2 PM	Agus gunawan, head of division of policy and mitigation planning	MEF office, Senayan, Jakarta	(MEF interview, 25 June 2018)
25-June	Directorate of research and community development, University of Indonesia	4 PM	Heri hermasyah, director	Depok	(DRPM UI interview, 25 June 2018)
	PT SWEN	5 PM	Sri Wahyuni, director Rahmat, staff	Bogor	(SWEN interview, 26 June 2018)
26-June	Climate change task force, MA	2 PM	Ai dariah, Mazwar	Bogor	(CTF MA interview, 26 June 2018)

Appendix 4: Co-benefits of biogas digester

- ☐ Biogas installations can reduce greenhouse gas emissions if properly managed. One biogas unit of 6 m3 can reduce 3.2 tonCO2/year (estimates based on Gold Standard). Greenhouse gas emissions that would otherwise come from firewood burning and livestock manure are replaced by emissions from burning biogas.
- ☐ Biogas installations have the potential to reduce forest degradation and firewood use. Firewood collection in protected forest areas is technically illegal, but forest rangers reportedly allow this so long collectors promise to take only the broken branches. Firewood use continued in the adopter households we visited due to 'easy access'; however, it seemed to be consumed in lower quantities. Farmers used firewood, particularly when cooking traditional dishes, or dishes that required the long time to prepare.
- ☐ With biogas units, less time was invested in firewood collection. Substitution of firewood with biogas reportedly saved up to 2 hours of a woman's time per day (and a child's time if they accompany their mother). Farmers indicated that this time saving was used for cooking, to socialize with others, to engage in cultural or community activities, and to spend in child education and household work. The additional time required to operate the biodigester has been reported in one study to be less than the time gained from avoided firewood collection (Guntur, 2015).
- ☐ The use of biogas stoves helps avoid indoor pollution when cooking. Smoke produced by burning firewood during cooking had reduced significantly, but not completely as farmers continued to use firewood for particular occasions (e.g. traditional festivities) and routine cooking.
- ☐ The use of biogas reduced the reliance on LPG in households that were already using LPG before the biogas installation. The use of LPG had reduced by half since biogas became available.
- ☐ Bioslurry is another product generated with the biogas installation. Bioslurry was used by farmers as organic fertilizer for their own land, and some were considering the option of selling it to other farmers to generate additional revenue. The use of bioslurry for fertilizer rather than commercial fertilizers was perceived to both increase crop yields because it is rich in nutrients and save money for farmers who reported that commercial fertilizers were expensive.
- ☐ Biogas production has the potential to generate electricity with pilot experiments currently on-going in several provinces. With electricity, farmers saw the opportunity for new small-scale businesses (e.g. production of crafts, fertilizer derived from cow urine) that can generate additional income (TRANSrisk, 2017)