

TRANSITIONS PATHWAYS AND RISK ANALYSIS FOR CLIMATE CHANGE MITIGATION AND ADAPTATION STRATEGIES

D3.2 Context of 15 case studies:

Indonesia: Bioenergy

Project Coordinator: SPRU, Science Policy Research Unit, (UoS) University of Sussex

Work Package 3 Leader Organisation: SPRU

Contributing organisation and authors: Stockholm Environment Institute (SEI): Takeshi Takama, Ibnu Budiman, Auditya Sari, Cynthia J. Ismail, Novelita Mondamina, Ivan G. Bobashev, Stefan Bößner, Timothy Suljada

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Contributing author(s):	SEI Ibnu Budiman, Auditya Sari, Cynthia J. Ismail, Novelita Mondamina, Ivan G. Bobashev, Stefan Bößner, Timothy Suljada)
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Table of Contents

1 Country case studies of the human innovation system (HIS): the enabling environment for sustainability	3
1.1 Research questions for the Indonesia case study	3
1.2 Introduction to the general context	5
1.2.1 Policy overview.....	6
1.2.2 Natural resources and environmental priorities	6
1.2.3 Economic priorities	10
1.2.4 Societal priorities perspective on climate change:	11
1.2.5 Politics of energy development priorities	13
1.3 The Human Innovation System Narrative	14
1.3.1 Overview of the development of the Indonesian bioenergy sector	14
1.3.2 TIS life cycle value chain: a cradle to grave analysis	14
1.3.3 Enabling environment: policy mixes in the socio-economic system	20
1.3.4 Enabling environment: government institutions.....	24
1.4 The Innovation System map	28
1.5 Stakeholder engagement.....	30

Figures

Figure 1 Economic sector share of total Balinese provincial GDP in 2013.....	11
Figure 2 Draft innovation system map for the value chain for biogas cooking fuel.....	29

Tables

Table 1 Installed capacity (MW) of Electricity State Company by type of power plant in Indonesia	7
Table 2 Electricity generated by PLN.....	8
Table 3 Selection of Indonesian policy instruments that might indirectly affect bioenergy developments	22
Table 4 Selection of Indonesian climate change and energy policies.....	23
Table 5 Institutional structure in Indonesia relevant to bioenergy in specific case study focus areas in Bali	25
Table 6 Stakeholder Engagement	31

1 COUNTRY CASE STUDIES OF THE HUMAN INNOVATION SYSTEM (HIS): THE ENABLING ENVIRONMENT FOR SUSTAINABILITY

Focusing on Indonesia for our case study, we seek to answer the following research questions: What contribution could bioenergy from sugarcane, rice and other feedstocks in Bali and East Java make to Indonesia's climate and energy targets, as well as to the country's sustainability objectives? What changes (institutional, market etc.) would be required in order to pursue these bioenergy transition pathways? And what would be the key enabling policies and measures to achieve these pathways' objectives? The assessment of associated risks and opportunities are pursued throughout the case study.

Secondary sources such as academic papers, reports, and regulations are limited in the areas of research for the case study. In some cases, information on these sources is not reliable and must be verified with primary research, particularly in the case of regulations which, even though published, may not necessarily be in operation. For these reasons, we prioritised the collection of primary information through stakeholder consultations and discussions in this deliverable. There are other TRANSrisk Work Packages that are piloting methods in Indonesia, such as Work Package 6 on innovation policies, which requires further primary data collection. The appendix of this report includes a summary of the first case study workshop, conducted in May 2016 in Bali, Indonesia, which is one of the main sources for primary data collection in this report.

1.1 Research questions for the Indonesia case study

- 1) What contribution could bioenergy generated from sugarcane, rice and one other selected feedstock in Bali and East Java make to Indonesia's national bioenergy, climate change and sustainable development goals?
 - a) How much bioethanol, biogas and biomass pellets could be generated from selected feedstocks using current and future technologies?
 - b) What are the economic, social and environmental priorities to be considered in exploiting this bioenergy potential?
 - c) Which specific bioenergy transition pathways with which combinations of bioethanol, biogas, biomass pellets are to be examined, based on these priorities?
- 2) What changes are required to pursue the identified bioenergy transition pathways?

- a) Which specific changes (technological options, institutional arrangements, behaviour changes, infrastructure changes etc.) are required?
 - b) What are the risks associated with the identified changes and how are these influenced by different scenarios (e.g. SSPs - shared socio-economic pathways including population, economic growth, etc)?
 - c) What are the interests and capabilities of actors involved to influence those pathways and how do connections between actors, as well as external pressures, influence the identified changes?
- 3) What are the key enabling policies and institutions to support sustainable bioenergy development from selected feedstocks in Bali and East Java?
- a) What policy options could help accelerate implementation of the identified bioenergy transition pathways?
 - b) What are the key uncertainties and what are they dependent on (e.g. technology, actors, external factors, etc)?
 - c) What are the risks and opportunities of the policy options connected to these transition pathways, given the uncertainties?

1.2 Introduction to the general context

Indonesia consists of between 13,000 - 18,000 islands and is home to almost 260 million people who are, although to a large extent Muslim, ethnically and culturally very diverse (The World Bank, 2015a). Like many lower income countries, economic development has been significant over the past decade. According to the World Bank, GDP rose steadily between 4 and 6% per annum even during the 2008-09 economic crisis even though a slowdown materialised in recent years (The World Bank, 2015b). This growth, fuelled by an increasing energy consumption, has gone hand in hand with rising emissions of greenhouse gases which make Indonesia the 7th largest emitter in the world (or even the 6th largest if emission from land-use change and forestry are factored in) (Friedrich et al., 2015). Here, it is, however, important to note, that per capita emissions are fairly low. At 2.3 tonnes of CO₂e, each Indonesian citizen released on average almost 6 times less than an average German, who released almost 9 tonnes of CO₂e into the atmosphere and less than 11 times the United States' per capita rate of 17 tonnes of CO₂e in the year 2011 (World Bank 2016) (The World Bank, 2015c). These trends - rising GDP, rising emissions and overall rising energy consumption - are likely to continue if no other policies are adopted. Indeed, the website Climate Action Tracker rates Indonesia's policies (see below) as "inadequate" in order to meet its pledged contributions (its Nationally Determined Contribution or NDC) to fulfil the recently adopted Paris Agreement (Climate Action Tracker, 2016).

These sub-optimal developments to meet internationally agreed climate mitigation targets are largely rooted in the prominent role the fossil fuel sector plays in Indonesia. In 2014, the country was the world's largest coal, and the world's 5th largest LNG exporter (PWC, 2016). Naturally, this position in world energy markets translates into significant revenues for the state. The IEA estimates that as much as 30% of government revenues come from the fossil fuel sector, which is in turn largely due to the predominant role the state plays in the energy sector. While fossil fuel production is diversified with international oil companies (IOCs) accounting for 70% of petroleum production, distribution and refining of crude oil and petroleum products is controlled by PT Pertamina, a monopoly company 100% owned by the Indonesian government (IEA, 2015a). The same holds true for the gas sector, where distribution and transmission capacities are firmly in Pertamina Gas' hands (IEA, 2015b). Coal production has greater private ownership and, as mentioned before, is of significant size, accounting for 322 million tonnes in 2015 (Indonesian Coal Mining Association, 2016).

It is this fossil fuel based "regime" as defined by Geels and Schott, 2007, against which new, innovative technologies such as biogas have to compete (Geels and Schot, 2007). Indeed, despite the Indonesian government's plans to tackle rising emissions, policies are sometimes not sufficiently well aligned to that goal.

1.2.1 Policy overview

Governing almost 260 million people dispersed on hundreds of Islands leads to institutional complexities. Indonesia's form of government is a presidential system where the president is elected directly by the people and draws up legislation together with the parliament (Kawamura 2010) (Kawamura, 2010). There are 34 ministries at national level. The decentralisation policies of the past led to a total of 34 provinces and 82,330 local government units, which all retain certain policy making power (GRAPHIQ, 2016).

The policy architecture itself is also complex. When it comes to climate policy, there is the NDC of Indonesia which sets a 26% emissions reduction target (41% with international help) by 2020 compared to business as usual (Republic of Indonesia, 2015). Nationally, this has been translated into the National Action Plan for Greenhouse Gas Emission Reduction (RAN-GRK) which confirms the objectives stated in the NDC. In the energy sector, the flagship project of the government is the 2014 National Energy Policy (NEP 14) which sets out, amongst other things, a target for the national energy mix. By 2025, 30% of energy should be sourced from coal, 25% from gas, 23% from Renewables and 22% from oil (IEA, 2016). In addition, Indonesia has set an interim target of a 19% share of renewable energies by 2019 (Mittal, 2015).

For the bioenergy sector, the government has put two targets in place: by 2025, 30% of diesel consumption should be met by biodiesel and 25% of gasoline should come from bioethanol. But both climate and energy policies are interacting with other policies such as the National Medium Term Development Plan 2015 - 2019 which seems to place more emphasis on traditional fossil fuel developments than on renewable energies (see below, 2.2.5). Those negative interactions between policies (which were identified as a hindering factor of successful bioenergy upscaling) were also mentioned several times by the participants of an international workshop co-organised by SEI in May 2016 in Bali in the framework of the H2020 projects TRANSrisk and GreenWin. These negative interactions or conflicts may find their root in the country's significant natural resource endowments that could be exploited for energy, as discussed in Section 2.2.2.

1.2.2 Natural resources and environmental priorities

According to a BP Statistical Review, 3.6 billion barrels of oil, 2.8 trillion m³ of natural gas and 28 billion tonnes of coal lie below Indonesia's surface. While indigenous oil reserves are small compared to other oil producing nations, 1.5% of the world's gas and 3.1% of the world's coal reserves are found in Indonesia. And unlike oil, which has an estimated reserve to production ratio of 13 years, Indonesia could extract coal from proven reserves for 70 years at current production. According to the IEA, that led to a total production of energy in Indonesia of 460 Mtoe (IEA, 2016b) in 2013, up from 331 Mtoe in 2007 (IEA, 2009).

However, this is not equivalent with domestic consumption where total final energy consumption stood at 159.7 Mtoe in 2012. Electricity consumption rose from 127 TWh to 198 TWh between 2007 to 2013. Of this the IEA estimates that most of it (37%) is consumed by the residential sector, 30.5% by the industrial sector with the transport sector accounting for 27% in 2015. (IEA, 2015b)

In the same year, the sectoral distribution of CO₂ emissions is as follows. Roughly 36% stems from the power generation sector which is largely dominated by coal power, about 29% arise from the transport sector with the industrial sector accounting for approximately 22% (IEA, 2015a). Contrary to its prominent energy consumption, the residential sector only contributes roughly 4% of the country's emissions.

However, besides fossil fuel endowments, Indonesia also holds a significant renewable and bioenergy potential. There are established renewable energy sources such as hydro power or geothermal, with estimates of a potential of up to 75 GW for hydro energy (IEA, 2015a) and 28 GW for geothermal. The latter is only used for five percent of this potential. (U.S. Energy Information Administration (EIA), 2015). Energy production potential from biomass, which includes plant matter derived from forestry, agriculture, and estates, particularly the palm oil plantations of Sumatra, is estimated to stand at up to 50 GW (ADB, 2015a). This means that renewable energy potential in Indonesia is roughly equivalent to current installed power generation capacity.

The report for year 2015 is still unpublished. However, at the end of 2014, the capacity of the power generation system in Indonesia was reported at 53,065,50 MW, while the electricity generated was 234,539.37 GWh (Directorate General of Electricity, 2015). Table 1 Installed capacity (MW) of Electricity State Company by type of power plant in Indonesia Table 1 below shows the installed capacity (MW) of the Electricity State Company (PLN) and the electricity generated by type of power plant:

Table 1 Installed capacity (MW) of Electricity State Company by type of power plant in Indonesia

TAHUN/ Year	PLTU/ Steam PP	PLTG/ Gas PP	PLTGU/ Combined Cycle PP	PLTMG/Gas Engine PP	PLTD/ Diesel PP	PLTA/ Hydro PP	PLTM/ Mini Hydro PP	PLTMH/ Micro Hydro PP	PLTP/ Geothermal PP	PLTB/ Wind Power PP	PLTS/ Solar PP	PLTGB/ Coal Gasifi- cation PP	PLTSA/ Waste PP	Jumlah/ Total
2009	12,594.00	3,135.88	8,009.97	71.00	3,256.36	3,694.95	6.03	0.69	1,189.00	1.06	-	-	-	31,958.93
2010	12,981.50	3,821.57	7,590.32	92.84	4,569.89	3,719.69	13.53	0.69	1,192.75	0.34	0.19	-	-	33,983.30
2011	16,318.00	4,236.02	8,480.97	169.54	5,471.93	3,880.83	57.66	5.93	1,209.00	0.93	1.16	41.00	26.00	39,898.97
2012	19,714.00	4,343.82	9,461.11	198.74	5,973.58	4,078.24	61.46	6.71	1,343.80	0.93	4.09	41.00	26.00	45,253.47
2013	23,812.53	4,389.09	9,852.21	448.12	5,935.00	5,058.87	77.05	29.69	1,345.40	0.63	9.02	6.00	26.00	50,898.51
2014	25,104.23	4,310.50	10,146.11	610.74	6,206.99	5,059.06	139.87	30.46	1,405.40	1.12	9.02	6.00	36.00	53,065.50

Source: (Directorate General of Electricity, 2015)

Table 2 Electricity generated by PLN

TAHUN Year	PRODUKSI / OWN GENERATED										PRODUKSI / OWN GENERATED				JUMLAH PRODUKSI PLN'S Pro- duction	PEMBELI- AN Purchase	JUMLAH Total
	PLTA Hydro PP	PLTP Geother- mal PP	PLTU-M Steam Oil PP	PLTU-G Steam Natural Gas PP	PLTU-B Steam Coal PP	PLTD* Diesel PP	PLTG-M Gas Tur- bine PP	PLTG-G Natural Gas PP	PLTGU-M Combined Cycle PP	PLTGU-G Combined Cycle PP	PLTM-G Combined Cycle PP	PLTS Solar PP	PLTBayu Wind Pow- er PP				
2009	10.306,91	3.504,47	9.030,99	795,22	43.137,63	10.431,80	4.270,63	4.403,85	12.122,07	22.624,61	0,00	0,10	0,00	120.628,28	36.168,92	156.797,20	
2010	15.827,35	3.398,02	6.712,34	1.009,46	46.685,22	11.925,81	5.227,11	4.038,96	11.484,68	25.327,03	73,56	0,50	0,02	131.710,06	38.076,16	169.786,22	
2011	10.315,55	3.487,39	6.382,67	1.003,02	54.949,55	16.125,11	7.658,38	2.359,33	13.519,71	26.889,96	47,67	0,72	0,00	142.739,06	40.681,87	183.420,93	
2012	10.524,61	3.557,54	2.391,14	4.798,64	66.633,27	18.913,02	5.384,03	2.926,22	5.953,07	28.615,44	55,12	2,85	0,00	149.754,94	50.562,62	200.317,56	
2013	13.013,95	4.345,09	1.054,86	5.602,06	75.192,74	18.919,32	5.812,03	3.145,83	4.295,49	32.197,13	381,75	5,48	0,00	163.965,74	52.222,79	216.188,53	
2014	11.163,62	4.285,37	722,98	5.153,58	83.372,81	21.861,54	3.173,29	5.943,64	38.068,45	731,38	51,06	6,81	-	175.296,97	53.257,93	228.554,90	

Source: (Directorate General of Electricity, 2015)

Both the electricity generated and the productivity capacity by power plant type experienced a sustained increase from 2009 to 2014. Coal continued to be the dominate energy source for electricity generation with over 53%, gas made up 25%, diesel contributed 9.7% while oil made a small percentage of 0.3% (all 2014 figures). From the renewable energy side, hydro had the largest share of around 6.7% while geothermal contributed around 4.45% and biomass only comprised of 0.091% in 2014 (Ministry of Energy and Mineral Resources, 2016).

Here, it is important to distinguish traditional biomass use as a cooking fuel and more innovative approaches that convert biomass to other useable forms of energy such as biogas and bioethanol. For example, rice straw, currently mostly untreated and left in the fields after the harvest, could be transformed into biogas by means of biomass gasification or anaerobic digestion, either on its own or mixed with animal waste. In the case of anaerobic digestion, milled rice straw mixed with animal manure has been found to increase yield and stabilise the production of gas (Ye, at.al, 2013).

In Indonesia, un-milled rice reaches around 75 Mt of a year, which would mean roughly 100 Mt of rice straw. Initial rough estimates based on stakeholder discussions undertaken through this case study, and initial analysis by the authors, indicate that if 100% of rice straws in Indonesia were collected, treated and used to generate biogas, 1.8% of Indonesia's power consumption could be met. While these hypothetical figures do not consider the significant collection and processing steps required to achieve 100% conversion, they nevertheless point to a significant potential, particularly on the household level.

At a regional level, it is estimated that Bali produces approximately 244-415 kt/year of rice straw (Samuel, 2013). Supposing all rice straw in Bali is converted to bioethanol through second generation cellulosic processing, the range of GHG reductions could be between 19 and 32 ktCO₂-eq (Samuel, V. 2013). Similarly, East Java produces the majority of Indonesia's sugarcane, which can be converted to ethanol. 29 grams CO₂e per MJ is produced during the

lifecycle of ethanol production and usage (Badan Pusat Statistik, 2014), a 67% reduction compared to gasoline (Khawid et al., 2016).

Exploiting this bioenergy potential is not without risks. This is especially the case when pursued in a non-sustainable manner, or when economic development is given priority over environmental protection, which is an often observed pattern in countries catching up with the industrialised countries (Azadi et al. 2011) (Azadi, H. et al., 2011). Land use demands are the most important driver of global land-cover change, affecting biodiversity, ecosystem services, and ultimately, human well-being (Foley et al 2005). The palm oil sector is one example. In 2012, Indonesia was the largest producer of this commodity in the world, producing about 26 million tonnes (UCSUSA, 2013). While this exploitation has economic benefits in providing export revenues and jobs, it has also led to significant land use change and deforestation in Indonesia. According to Wicke et al. (2011), Indonesian forests have been reduced by 30% (or 40 million ha), making this a prominent environmental problem (Wicke, B. et al., 2011). Although data at the national level is patchy and often not readily available, the researchers qualify land use change directly related to palm oil cultivation as “significant”. Other researchers attribute palm oil cultivation as being responsible for 50% of the 40 million ha loss (ibid. p. 194). This is also worth considering when talking about other bioenergy developments in this country. It not only limits first generation bioenergy upscaling, but, under certain conditions, also second generation bioenergy developments where demand for the crop is extended from food to bioenergy.

Other environmental priorities in Indonesia include, in brief:

- Air quality in large urban areas. Jakarta has been shown to be one of the most polluted cities in the world (Both et al. 2013) (Both, A. F. et al., 2013).
- In the medium and long term climate change is expected to lead to some significant water shortages, and subsequent droughts, in regions such as Bali, Java and East Nusa Tenggara (Ministry of Environment, 2010). In addition, coastal areas are greatly affected by climate change due to the projected rise in sea level, and thus the Indonesian government must prepare long-term adaptation strategies in response (Measey, 2010).
- Freshwater availability and sea management is especially relevant to Bali. Fresh water access might be compromised by longer dry periods, salt-water intrusion in the water table and potentially contamination by pollutants as settlements and industry expand over time also due to increasing tourism.
- The rehabilitation and management of coral reefs is considered another issue (The World Bank, 2014).

1.2.3 Economic priorities

President Widodo narrowly won the last election, based on a promise to reform Indonesia's entrenched governing structures as well as the economy (Tisdall, 2014). And indeed, since September 2015, the government has unveiled at least 12 reform packages, including those aimed at removing red tape, cutting fossil fuel subsidies and facilitating the attraction of foreign investment (Hayden, 2016). But growth had recently slowed and the World Bank ranks Indonesia 109th for ease of doing business in the world (fellow ASEAN countries like Thailand and Vietnam are ranked 47th and 90th respectively) (The World Bank, 2015c). Therefore, a priority of the government is to tackle structural problems and widespread corruption, as well as maintaining and ambitious reform agenda to ensure continuous economic growth.

However, maintaining momentum for economic reform while simultaneously gearing energy production and the economy towards a more sustainable pathway is easier said than done. This particularly holds true in Indonesia, where several barriers to sustainable development remain. Economic growth might be given priority over environmental issues, as illustrated by simultaneous development of coal and renewable power. Moreover, Indonesia's geographical complexity and the subsequent bureaucratic structural issues (thousands of sub-national government entities) make it more prone to lack of transparency and corruption issues, as argued in Kirana 2014 (Kirana, 2014). In addition, low commodity prices have stalled investment, particularly in clean energy infrastructure (OECD, 2015), and the falling Rupiah is considered a problem for establishing, for example, a functioning market for bioenergy (See Workshop Report and SEI Country Brief). Moreover, tax revenue is low due to tax evasion and the complex, decentralised geography, which may leave the government with less money than needed to make its ambitious bioenergy targets become reality (OECD, 2015). Indeed, raising government tax revenues and investing in infrastructure, particularly transport, is a key recommendation by the OECD (OECD, 2015).

On the policy side, three strategies set economic development goals: the National Long Term Development Plan (RPJPN), which is divided into several National Medium-term development plans (RPJMN), and the Masterplan for Acceleration and Expansion of Indonesia's economic development (MP3EI). The latter pursues three main objectives: increase value-adding for industrial processes, encourage producing efficiency and market integration and encourage the national innovation system (Indonesia Investments, 2016). And while plans such as the current RPJMN (up to 2019) include commitments to the green economy and sustainable development as the backbone of Indonesian development (Grantham Research Institute, 2015a), other policies, for example in the energy sector, might work counter to this policy. Indonesia has recently sought to shift energy supply from international markets to domestic ones, as stipulated in the NEP 2014, in order to meet rising domestic demand (IEA, 2015a) and fossil fuels still dominate the energy mix according to the NEP 2014 and RPJPN.

In Bali, the focus of our case study, tourism is a main economic priority, accounting for around 30% of the provincial GDP in 2013 as shown in Figure 1. This might negatively affect the developments of bioenergy sources. Balinese tourism is highly connected to the agricultural sector because of the natural beauty of terraced rice paddies and other agro-tourism attractions. At the same time, agricultural land and crops have been reduced by tourism-related property development (Parker, 2013). There is also a draw on the agricultural labour force towards the tourism industry, particularly among the younger population. According to the Bali Labour and Transmigration Agency, there were more than 300,000 productive age workers in the tourism sector in 2015. Tourism also tends to drive up the cost of land, placing pressure on agricultural land areas. All those dynamics may affect the upscaling of bioenergy from, for example, rice husks and rice straw, a technology which would depend on additional labour in the rice fields and the lands on which the paddies are located.

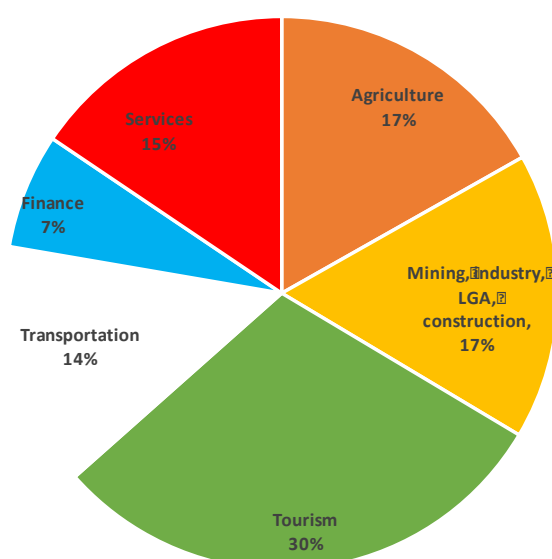


Figure 1 Economic sector share of total Balinese provincial GDP in 2013

Source: (Bali Statistics, 2013)

1.2.4 Societal priorities perspective on climate change:

As of 2015, the population of Indonesia stood at around 258 million people with a population density of 142 people per square kilometre (The World Bank, 2015a). Indonesia still has about 11 % of the population living below the poverty line, for which the Government has set a target of 4% by 2025 (INDC Indonesia, 2016) despite the fact that population is expected to reach around 310 million people by 2050 (Kohler, H.-P., Behrman, J.R., Arianto, D., 2015).

Those people are spread across a land area of 1,811,570 km² and a sea territory of a further 3,150,000 km² which makes Indonesia the largest island nation in the world and the 14th largest country by landmass (The World Bank, 2016), (Boken et al., 2015).

Indonesia's Ministry of National Development and Planning (Bappenas) is responsible for leading the Government's implementation of the Sustainable Development Goals (SDGs), adopted at the United Nations Summit in New York on 25 September 2015. Bappenas, along with other ministries and international development partners, have co-hosted several events aiming to build understanding of the SDGs and pursue their implementation (Sustainable Development Solutions Network, 2016). The Directorate General of Climate Change, under the Ministry of Environment and Forests (KLHK), deals with climate change issues.

From a societal perspective, the first case study workshop, held in May 2016 in Bali, yielded further insights into the knowledge about, and the social acceptance of, bioenergy and climate change. When it comes to information about climate change mitigation actions and associated technologies, the lack thereof was seen as a potential barrier by workshop participants. Often, people seem to be simply not aware of certain mitigation solutions such as biodigesters to turn animal and crop waste into biogas, or efficient cook stoves fuelled by wood pellets. In addition to this lack of information, workshop participants also pointed out that the lack of training in maintenance of existing bioenergy equipment, such as biodigesters, would be a further barrier to increased bioenergy uptake. Moreover, cultural practices might pose some problems. Biogas derived from pig dung for example, while generally unproblematic in Bali, might encounter difficulties in Muslim Java.

Other forms of bioenergy, such as the use of wood pellets, seem to pose less problems in terms of social acceptance. Approximately 60% of Indonesian households rely on traditional biomass (mostly wood) for cooking (Lamarre-Vincent, 2011). Most of these households are in rural areas and are likely to continue using traditional biomass in the near future. Workshop participants seemed to be keen on using wood pellets, as they saw several advantages. Generally, a wood pellet stove is easy to use, although having less capacity than traditional stoves due to limitation on how many pellets (enough only for 1-2 hours of cooking) an oven can hold. Most importantly, wood pellet stoves produce less smoke than firewood fuelled cooking facilities and can reduce workload, particularly for women who are mainly responsible with collecting firewood, a task which is no longer needed when using wood pellets stoves (see workshop report). Overall, it seemed that while there appears to be awareness of climate change and environmental issues, detailed knowledge is often missing.

1.2.5 Politics of energy development priorities

Indonesia's appetite for energy is increasing due to economic development and population growth, and its energy policies oscillate between satisfying increasing energy demand cost-efficiently and sustainability targets. The government has responded by, on the one hand, shifting energy exports to domestic markets and, on the other hand, by prioritising fossil fuel developments in some areas, which may run counter Indonesia's renewable energy and emission reduction targets. For example, the government has adopted the so-called "fast-track programme" for building power plants more quickly, which aims to fill the gap between power generation capacity and political targets to bring electricity to all citizens of the government. However, more than 55% of new power plants planned under the government's third fast track programme (or 19.6 GW by 2019) are expected to be coal-fired according to the Asian Development Bank (ADB, 2015).

Nevertheless, Indonesia has recently established the Clean Energy Centre of Excellence (CoE) in Bali, led by the Ministry of Energy and Mineral Resource (MEMR), to support the government target of 23% renewable energy in the energy mix by 2025 (Ministry of Energy and Mineral Resources, 2015). For a period of four years, the centre will focus on supporting efforts to develop the 35 MW electrification programmes, of which 25% (or about 8.8 GW) will come from renewable energy. The CoE aims to enable a concerted effort in developing and deploying new renewable energy by bringing together national and international expertise and public-and private-partnerships to assist in the transfer and deployment of technologies. Its main functions are knowledge support, the facilitation of learning and the facilitation of investment related to clean energies. The establishment of the centre indicates a strong commitment to renewable energy development, despite the aforementioned policy incompatibilities.

However, ambitious policies are often implemented in a sub-optimal manner in Indonesia. For example, the central government took the bold decision to remove almost all energy subsidies and reallocate its budget to welfare programs and infrastructure (Lontoh et al., 2015). While this is an important step to establishing a more cost-effective energy market, new problems have arisen at the local level due to incompatibility of implementation by central and local governments. Although success cases are reported (Pradip tyo et al., 2016), many people have responded negatively to subsidy removal plans, as the negative impact on household budgets is perceived to be greater than the promised benefits in the form of welfare and infrastructure (Widodo et al., 2012). While social safety net programs have been established to reduce the impact of fuel price increases on the poor, there are instances where these are poorly targeted or badly coordinated, leading to many citizens failing to receive their entitlements (ADB, 2015b).

See section 1.3.4 'Enabling environment: government institutions' for further details on the political system.

1.3 The Human Innovation System Narrative

1.3.1 Overview of the development of the Indonesian bioenergy sector

The Indonesian case study seeks to answer three research questions. Firstly, what contribution could bioenergy from waste products (rice and other selected feedstocks) in Bali and East Java make to Indonesia's climate change and sustainable developments goals? Secondly, what changes are required to pursue the identified bioenergy transition pathway? And finally, what are the key enabling policies and institutions to support sustainable bioenergy developments in Bali and East Java?

Bali and East Java were chosen due to the regions' biomass endowment: Java and Bali together account for more than 50% of the nation's rice production while Java accounts for the overwhelming majority of Indonesian sugar cane production (Second National Communication Report, 2010). These are major feedstock when it comes to producing bioenergy. For example, while sugarcane can be used directly to source bioethanol, residues from rice production, such as rice straw and rice husk, could be used to generate biogas as well as second generation bioethanol. Moreover, the aforementioned Clean Energy Centre of Excellence is to be implemented in Bali, which provides access to policy makers, researchers and business stakeholders working on the promotion of renewable energies.

Also, Bali and East Java are already home to several bioenergy pilot projects. For example, Bali has a clean energy and an integrated farming programme, which foresees the distribution of live feedstock (cows, pigs) and the installation of so called biodigesters in order to transform animal manure and other organic waste (like rice straw) into biogas. As part of a first pilot project in 2015, 134 biodigesters were installed in the Jembrana Regency in West Bali. Private players are also active in the field of bioenergy. Dutch NGO Hivos, for example, in cooperation with MEMR and the Dutch development agency, run a project called BIRU, which built more than 11000 bio digesters in Indonesia (Hivos, n.d.). There is also a biomass wood pellet gasification and cookstoves pilot under way in Tukadaya Village, Jembrana Regency in Bali, led by the state owned Gas Company (PGN).

1.3.2 TIS life cycle value chain: a cradle to grave analysis

Based on stakeholder consultations held to date, we have identified the following four innovation system value chains where agricultural residues with the greatest potential in Bali and East Java can be used to produce bioenergy:

1. Biogas cooking fuel from rice residues, animal manure and household waste.

2. Biogas-generated electricity from rice residues and animal manure.
3. Biomass pellets from rice residues.
4. Bioethanol from sugarcane bagasse and Napier grass.

Each of these value chains is outlined in brief in this section, based on the findings from the first Indonesia workshop held in May 2016. Further information about the workshop is presented in Appendix A.

Group exercises at the workshop were designed to identify vulnerable production steps and significant issues along the value chain, which could negatively affect bioenergy development. For the exercise, participants were asked to attribute numeric values from 0 to 3 for each step in the value chain related to the issue area according to the following rating system:

- 3 = significant difficulties in this step of the value chain occur that cannot be managed
- 2 = medium difficulties occur which can be managed
- 1 = few difficulties occur
- 0 = no difficulties in this step of the value chain

After extensive discussions, each group was asked to present the value chain steps where the most difficulties had been encountered.

1.3.2.1 Biogas cooking fuel from rice residues, animal manure and household waste

At the workshop, a group of stakeholders, including researchers, biogas developers, non-government agencies and farmers, discussed the difficulties encountered in the value chain for biogas from rice husks and other materials (rice straws, manure and food wastes) for small-scale applications. The schematic value chain of this technology is presented below while its system map can be seen in section 1.4.

1. *Plantation*: rice cultivation at the village scale.
2. *Feedstock*: all organic household waste, rice residues from rice cultivation and the manure from livestock farming covers the main feedstocks available for the process.
3. *Collection*: all feedstocks require dedicated transport, which will affect the annual costs.
4. *Processing*: through pre-treatment and anaerobic digestion, which can be more profitable by using one large scale biogas plant rather than several medium sized plants.
5. *Production*: biogas and bio-slurry through anaerobic digestion.
6. *Distribution*: to end-user for cooking through gas pipeline network.

7. *End user*: household, industry and restaurants.

Biodigesters, as presented in this value chain, are already in use today in Jembrana Regency through the above-mentioned BIRU and government-led pilot projects. It is important to note that the difference between BIRU's successful digesters and the government's less successful digesters is that the BIRU program includes training and maintenance. Also the BIRU programme provides a 20% co-payment for installation costs with the remainder met by the user, compared to the fully subsidised government program. The results are quite clear with HIVOS having installed 947 digesters with only 1.5% not working, whilst 50% of digesters installed by the government programme no longer working. The reasons for these biogas digesters not functioning has been primarily attributed to a lack of maintenance.

From the experience of the pilots and their theoretical background, the stakeholder group identified a few barriers. For example, rice straws are only available during harvest, which serves as a barrier for continuous production of biogas, as it is a seasonal or cyclical product, whereas organic waste (animal waste as well as kitchen waste) is available daily. A different problem arises in that today's digesters lack the technology to process both animal and kitchen wastes. As such, rice husks or straws are not the primary feedstock to be used for digestion. One new method to process rice straws into biogas involves the use of enzymes similar to enzymes inside animals' guts (Narra et al, 2016).

Moreover, the participants saw the quantity of rice straws and husks as being insufficient for producing biogas, and that animal manure would also be required in order for the anaerobic digestion process to function.

Changes in land use in Bali has become an issue for the biogas development, as farmers have greater financial incentives to sell their land for business development. It is also affected by the decreasing availability of labour for farming, especially planters who would be needed to labour in the rice fields. A lack of financial support for biogas investments was also identified as a significant barrier.

1.3.2.2 Biogas-generated electricity from rice residues and animal manure

Large scale biogas production from rice residues was discussed by a group of workshop participants, including researchers, private developers and government agencies. The following value chain was established by the workshop participants:

1. *Plantation & Harvesting*: there are no any significant difficulties in the plantation stage given the available technology, the institutional support for plantation is sufficient therefore economically viable. There are plenty of rice cultivations and livestock which can produce rice residues and manure.

2. *Feedstock*: farmers found that one tonne of rice grains would yield one tonne of rice straws. It will be an additional feedstock together with cow and pig manures.
3. *Collection and Transportation*: feedstock needs to be collected and transported from cultivation and livestock cages to biogas installations. This is problematic because feedstock is widely distributed in many different locations and transportation has to go through different types (and quality) of road.
4. *Processing*: two technologies for large-scale bioenergy from biogas were identified, namely biomass gasification to produce synthetic gas for electricity production and large-scale anaerobic digesters to produce biogas.
5. *Production*: biogas from anaerobic digestion and electricity from biomass gasification.
6. *Distribution*: needs the installation of transmission lines, either on grid or off grid, which could be a hindrance, particularly where the plant is far from the end-user location.

Workshop participants stated that this value chain did not look promising due to issues related to economic viability. Fertiliser usage is believed to be a more realistic use for rice residues. Participants agreed that, while technologies are available, they are very import-dependent, meaning that lots of spare parts and machines are imported from foreign countries. This can sometimes lead to long and time-consuming processes to acquire all the necessary parts. Moreover, “economic viability” was identified as problematic, since the necessary skills amongst local labourers are in short supply.

In terms of land use, the high cost of land in Bali makes it more difficult for large scale biogas developments. Location and space are becoming a problem as commercial scale activity needs land acquisition to build the biogas plant. However, participants stressed the fact that this would be a problematic issue even for other energy projects. This is in line with findings in the literature which points out the difficult legal situation concerning land rights (see section 1.3.3.). Stakeholders in the workshop agreed that people should be well informed about land use for bioenergy developments. Currently, the management of land use is insufficiently regulated. It therefore requires close cooperation between local communities, public and private sectors to solve the problem. Once it is clear, it will encourage banks to provide funding. However, this may only apply to particular banks, as financing pipe installations is costly and risky from the banks’ perspectives.

Participants felt that social acceptance of large scale biogas production has not yet been tested, but would follow once issues related to technology availability and economic availability were addressed. Economic issues are therefore a more significant hindrance of project implementation than social acceptance at this early stage.

1.3.2.3 Biomass pellets from rice residues

This value chain was discussed by a group of farmers, village leaders, researchers, financial institutes, small business owners and bioenergy developers. The value chain scheme devised and discussed by the participants is presented below:

1. *Land management*: converting rice residues into biomass pellet requires new technologies, which consumes land. It could raise issues with the Subak Abian method, a Balinese traditional organisation of farmers in the neighbourhood area of a village which mainly aims at sharing responsibility in the management of gardens and cropping patterns to improve the welfare of farmers.
2. *Fertiliser and Pesticide*: rice cultivation has to achieve optimum productivity to gain maximise rice residues production. The insufficient use of fertilisers affects the growth of the rice; farmers often do not have the financial capacity to buy proper fertilisers.
3. *Plantation and harvesting*: locals need the implementation of technology in order to optimise harvesting and decrease the manual methods for farming. For instance, advanced harvest machinery for threshing, drying and milling which accelerate production of rice residues for pellets.
4. *Transportation*: rice residues have to be transported from the cultivation area to a pellet factory. Financial support is needed for vehicles, and to improve the road infrastructure, for easing the delivery.
5. *Drying, Storage & Milling*: these processes will be carried in pellet factories, in order to convert rice residues into pellets. To enable collective processing, factories should be owned by farmers' group.
6. *End Use*: pellets can be used by farmers and the community with particular stoves. However, lack of information and access to clean cook stoves limits demand for the pellets.

Biomass pellets from rice residues is the subject of a pilot project in three regencies in Indonesia. Currently in the Jembrana regency, communities receive few stoves from state-owned gas company (PGN), with the pellets being sent from other regions. Twenty households in the village were selected through deliberations amongst the villagers themselves to pilot the biomass pellet cookstoves in place of traditional open fire cookstoves. Each household was provided with one cookstoves and subsidised biomass pellets, imported from a facility in East Java. The result of this pilot will be consideration by PGN on whether or not to expand the biomass pellets pilot. In Jembrana, the pilot took place from January to June 2016.

Workshop participants generally agreed that the value chain was lacking institutional support from the local government. This lack of support would also affect numerous

problems identified in the value chain, such as at the drying and storage stage and the available financial support.

Stakeholders furthermore recommended that a pellet factory should be built near the village (rather than some distance away) to enable efficient biomass production. It was suggested that this could be done in a public-private partnership with the farmers. Farmers would need to be educated on how to undertake the maintenance of the machines and should be prepared to change the usage of energy sources (switching from fossil to bioenergy). However, participants were of the opinion that the economic viability of such a project seemed unclear, and identified this as a potential issue.

As with the “rice and animal waste to biogas for electricity use” value chain, stakeholders noted that reliable machines are rather expensive and often imported from abroad. A small scale pellet factory using a machine from Germany has the potential to produce 5 tonnes of pellets per hour but would cost IDR 19 billion, while a cheaper Chinese machine would cost only IDR 1.9 billion for producing the same amount. Meanwhile, on a small individual scale, manual labour can only produce 3 tons of wood pellets per day.

1.3.2.4 Second generation bioethanol from sugarcane bagasse and napier grass

The last value chain analysed, bioethanol from sugarcane bagasse and napier grass, is presented below.

1. *Plantation*: sugarcane is one of main commodities in East Java and napier grass is widely distributed in East Java lowland.
2. *Feedstock*: sugarcane bagasse can be collected from sugarcane plantations by coordination with the farmers and plantation companies. For napier grass, this is easier since it is available in large quantities in central locations.
3. *Collection*: the feedstock needs to be collected from the sugar plantations, which in the example discussed in this exercise/the workshop is located next to the sugar company, making it unproblematic.
4. *Processing*: converting the feedstock into bioethanol requires second generation bioethanol technology which the group understood requires a license from Italy and America. It requires a large amount of investment and the logistics are expensive.
5. *Production*: the second generation process uses a distillation method with cellulose, hemicellulose, and lignin enzyme to degrade the lignocellulose. The injection (blending between fossil fuel and ethanol) can be processed by Pertamina, with limited technology.
6. *Distribution*: the bioethanol needs to be distributed from the bioethanol company to Pertamina (the buyer) and blended in existing fuel depots, making it unproblematic.

7. *End user*: Pertamina is currently selling bioethanol for transport fuel to the community; however, the costs remain a barrier unless subsidies are provided.

Stakeholders in the workshop group discussing bioethanol production included NGOs, village leaders, Government agencies, financial institutes, researchers and small business owners. The group decided to analyse bioethanol production from “bagasse” (sourced from an unidentified sugar company) and “Napier grass” (cultivated specifically as an energy crop as a backup source to bagasse) as feedstock examples for the exercise.

State owned PERTAMINA has planned a bioethanol production facility which needs a consistent supply of feedstock, and has started to farm Napier grass in an 80,000 ha area as a substitute feedstock for bioethanol production. A Napier grass plantation of around 9,000 ha would produce the equivalent of 300,000 ton of bagasse a year. This optimisation strategy would allow substitution of bagasse for Napier grass in order to maintain the sustainability of feedstock in the event sugarcane bagasse is not available in sufficient quantities. Since bagasse is used to generate steam and electricity for use at the factory, obtaining a sufficient surplus would require installation of cogeneration systems significantly more efficient than those currently used in Indonesia (Khataiwada et al, 2016).

The stakeholder group found that the main obstacles for a successful implementation arose in the production and end user stage. PERTAMINA is reluctant to distribute bioethanol-blended fuel at the same price as standard gasoline because it would not cover costs. Another obstacle is the lack of government commitment on subsidies or the regulation of the market price. The stakeholders clearly saw the responsibility lying with the government to provide support by giving incentives to bioethanol companies. Furthermore, the end users were attributed a high difficulties score, since the group assumed that they were unwilling to pay higher prices for bioethanol.

1.3.3 Enabling environment: policy mixes in the socio-economic system

Indonesia’s institutional complexity is partly due to its vast geography, which also affects the policy mix of Indonesia. This is because policies have to be implemented at a range of scales, often in a very specific context given the rich cultural diversity in Indonesia. Plans for economic development, for example, are adopted at the national level, like the National Long Term Development Plan (RPJPN) which governs the Indonesian economy. This plan is itself split into several 5 year cycles which are called the Medium Term Development Plans (RPJMN) (APEC, 2011). Those plans in turn have a regional and local counter-part where they are called Medium Term Local Development Plans. The same holds true for the National Action Plan for Reducing Greenhouse Gas Emissions (RAN-GRK) and its local counterpart, the RAN-GRK (Governor of Bali, 2012).

However, those are not the only policies which are likely to have an impact on bioenergy developments. For example, a new interpretation by the Constitutional Court of an existing forestry regulation may affect new geothermal developments, as it has handed back land ownership of previously government-owned land to local communities (Kurniawan, 2014). Local communities may also find it more profitable to sell land to be used as business development area, and not as area for feedstock cultivation or bioenergy.

Table 3 identifies a selected broad set of policies, operating not directly in the energy system, but in policy areas that might affect bioenergy developments. These can also pose trade-offs between policy objectives. For example, the National Action Plan for Greenhouse Gas Emissions reduction (RAN-GRK) clearly states that economic growth must not be hindered (Pratiwi, 2014), while The National Medium Term Development Plan (RPJMN) foresees many infrastructure developments which might be counter to emission reduction objectives.

Table 3 Selection of Indonesian policy instruments that might indirectly affect bioenergy developments

Policy themes	National	Regional (Bali and others)
General/ Economic	<p>National Long Term Development Plan (RPJPN)</p> <ul style="list-style-type: none"> ➤ Until 2025, split in 5 stages which form the: <p>National Medium Term Development Plans (RPJMN)</p> <ul style="list-style-type: none"> ➤ Current: up to 2019; goals: infrastructure developments & investment <p>Masterplan for Acceleration and Expansion of Indonesia's Economic Development (MP3EI)</p> <ul style="list-style-type: none"> ➤ 2011-2025, expand economic growth better regulation (Shira, 2011) 	<p>Medium Term Development Plans (RPJMD)</p> <p>Local Development Plans (RPJMD)</p>
Climate	<p>National Determined Contribution (NDC)</p> <ul style="list-style-type: none"> ➤ -29% by 2030 <p>National Action Plan for Reducing Greenhouse Gas Emissions (RAN-GRK)</p> <ul style="list-style-type: none"> ➤ -26% by 2020; 41% with int. support <p>Indonesian Climate Change Sectoral Roadmap (ICCSR)</p> <ul style="list-style-type: none"> ➤ -20% by 2020 with long-term development plan in particular sectors: Water, Marine, Fisheries, Agriculture, Health, Transportation, Forestry, Industry, Energy and Waste. 	<p>Local Action Plan for Greenhouse Gas Reduction (RAN-GRK) (Ge et al., 2016)</p> <ul style="list-style-type: none"> ➤ Mandated by RAN-GRK, all 34 provinces will come up with one
Technology	<p>Several Technology Transfer Regulations</p> <ul style="list-style-type: none"> ➤ PERMENKE, Presidential Regulation 27/2013 	
Finance	<p>Several grants for SMEs</p> <ul style="list-style-type: none"> ➤ LPND, KUR, PROLIPTTEK but deemed not sufficient (Simamora, 2013) <p>Law No. 25 on Investment (Damuri and Atje, 2012)</p> <ul style="list-style-type: none"> ➤ Lies down procedure for investment, also in energy sector <p>MOF Regulation No.26/2010 (Tumiwa and Imelda, 2014)</p> <ul style="list-style-type: none"> ➤ Indonesia Infrastructure Guarantee Fund; provides guarantees to attract private capital <p>MOF Regulation 117/2006 & 79/2007 (Tumiwa and Imelda, 2014)</p> <ul style="list-style-type: none"> ➤ Low cost loans for farmers that plant energy crops 	
Agriculture and forests	<p>Forestry Law No.41 of 1999</p> <ul style="list-style-type: none"> ➤ Recently interpreted by court rule (2013) which might make it more difficult to use lands & forests for bioenergy developments (Kurniawan, 2014) 	

In other policy areas, the complexity and potential trade-offs become even more apparent, as the energy sector illustrates. For example, as table 4 shows, energy policies for renewables development are manifold and often specifically adopted to one region. While this might be indeed necessary given Indonesia's size, it also creates additional complexity and uncertainties in terms of competencies.

Table 4 Selection of Indonesian climate change and energy policies

Name of Policy	Policy Area	Regional / National	Description/Objectives
Regulation No. 79/2014	Cross-cutting	National	The new National Energy Plan (NEP14) which contains, amongst others, the national renewables targets. Also, the re-directing of energy sources from export markets to domestic usage is enshrined in the law.
Geothermal Law No. 17/2014 (IEA, 2014)	Geothermal Energy	National	Introduced feed-in tariffs (FiTs) for geothermal, differentiated by a geographically based tariff regime. Also, the tariff is enhanced with an added dimension of the timing of achieving Commercial Operation Date. The ceiling price will increase for projects that have a more distant planned Commercial Operation Date (to cater for the effects of inflation).
Geothermal Law No. 21/2014	Geothermal Energy	National	Geothermal developments are no longer considered mining activities; this should facilitate increased use of geothermal energy.
Presidential Decree No. 61	Emission reductions	National	Stipulates, amongst other things, the Indonesian emission reductions, confirmed by the country's NDC (INDC)
MEMR Regulation 12/2015	Transport	National	This regulation amends blending targets for biofuels. By 2025, 30% of diesel consumption (in all sectors) should be biodiesel. A 20% blending target exists for bioethanol.
Ministry of Finance Regulation No.3/2012 (IEA, 2012a)	Geothermal	National	Introduced finance for survey and exploration services.
Ministerial Regulation No. 04/2012	Electricity; Small and Medium Scale renewables	National	Introduced feed-in tariffs (FiTs) for renewable energies.
Ministerial Regulation No. 27/2014 and No. 44/2015	Feed-in tariffs for biomass and municipal waste	National	This regulation revises earlier FiTs for biomass, differentiated by low or high voltage grid and depending on location of the installation
MEMR Regulations No 17/2013 (IEA, 2013)	Power purchase	National	Introduced solar auction programme in Indonesia. Certain prices are applied for

	from solar photovoltaic plants		power purchase from solar installation. PT PLN is obliged to purchase electricity generated from solar photovoltaic projects on the basis of Power Purchase Agreements (PPAs) for period of 20 years.
Ministerial Regulations No. 20/2011 and No. 22/2012 (IEA, 2012b)	Geothermal	National	Regulated the power purchase tariff of electricity from geothermal resources. PT PLN obliged to purchase electricity generated from geothermal plants inside Working Area of Geothermal Mining at a maximum price. This tariff shall be stabilised in a Power Purchase Agreement, be final and without negotiation.
MEMR Regulations No. 02/2011(IEA, 2011)	Geothermal	National	Obligation for PT. PLN to purchase geothermal electricity in accordance with tendered FiT levels.
Ministry of Finance Regulations No. 21/2010 (IEA, 2010)	Multiple renewable energy sources	National	Adjustment to income tax on energy development projects, including net income reduction, accelerated depreciation, dividends reduced for foreign investors and compensation for losses.
Provincial Regulations No. 5/2012 (Provincial Government East Java, 2012)	Multiple renewable energy sources	Province of East Java	Development plan of renewable energy in potential locations in East Java.
Governor Regulations No. 16/2015 (Governor's Office of East Java, 2015)	Multiple renewable energy sources	Province of East Java	Permission to explore renewable resource potentials in East Java.
Governor Regulations No.74/2010 (Governor's Office of East Java, 2010)	Multiple renewable energy sources	Province of East Java	Priority of renewable installation in East Java: solar, wind and hydropower.
Governor Regulations No.16/2009(PRO VINCIAL GOVERNMENT BALI, 2009)	Multiple renewable energy sources	Province of Bali	Development plan of renewable energy in potential location of Bali.

1.3.4 Enabling environment: government institutions

Indonesia is a presidential representative democratic republic, with an elected president (nominated by Indonesian political parties) being the commander in chief and simultaneously the head of state and head of government (Embassy of Indonesia, Athens, 2010). Interestingly, the president also plays a key role in energy policy by chairing the National Energy Council (NEC), which is the main body governing energy policies. The vice president, as well as the minister of the Energy and Resources Management Ministry (MEMR), are co-chairs. Other important ministerial representatives of this board are the Ministry of

National Development and Planning (BAPPENAS) and the Ministry of Environment and Forests (KLHK) amongst others, the latter important for land-use and forestry issues.

The National Council on Climate Change was disbanded in 2015, and is now part of the KLHK as the Directorate General of Climate Change (Grantham Research Institute, 2015b). This is interesting from an institutional perspective, as where energy policies are coordinated by an entire council, climate change issues are mainly addressed within the Ministry of Environment and Forests. Whether a subordinate role of climate change compared to energy issues can be assumed needs to be confirmed by further research, but indications are that this is the case. However, since the fall of the Suharto regime, Indonesia has gone through some significant change when it comes to governance. Decentralisation has increasingly given power to the provinces (Noor, 2012), with policy making authority resting with provincial and sub-provincial authorities in addition to national ones. This is a complex web of responsibilities, which is best explained through our case study's focus area of Bali. In table 5, we outline examples of specific institutions relevant to our case study, including those within the governmental structure and a parallel traditional structure called the Subak, which is specific to the Province of Bali. The Subak is a cooperative water management and irrigation system, which is important for village-level decision-making.

Table 5 Institutional structure in Indonesia relevant to bioenergy in specific case study focus areas in Bali

Name of institutional unit	Government or traditional structure (English / Bahasa)	Leadership, funding and instruments of authority
Indonesia <i>Central agencies</i> <ul style="list-style-type: none"> • Presidential Office of Indonesia • National Energy Council <i>Ministries</i> <ul style="list-style-type: none"> • Ministry of Finance • Ministry of National Development and Planning (BAPPENAS) • Ministry of Agriculture • Ministry of Energy and Mineral Resources <i>State owned companies</i> <ul style="list-style-type: none"> • PT Pertamina • Perusahaan Gas Negara 	National / Negara	<p>A directly elected President is head of the Executive arm of Government, who appoints Ministers to oversee specific policy portfolios.</p> <p>Each individual Ministry is headed by an appointed Minister.</p> <p>Funding: Ministry of Finance through national budget</p> <p>Instruments of authority include: Presidential Decree Ministerial Regulation</p>
Bali <ul style="list-style-type: none"> • Public Works Agency • Agriculture Agency • Plantation Agency • Animal Husbandry Plantation 	Provincial / Provinsi	<p>A directly elected Governor is head of the provinces. Each individual agency is headed by an appointed Head of Provincial Agency and each division is headed by an appointed Head of Provincial Division</p> <p>Funding:</p>

- Ministry of National Development and Planning (BAPPENAS) called general allocation budget /Dana Alokasi Umum (DAU) and special allocation budget (DAK)
- Development Planning Agency at Sub-National Level (BAPPEDA) called Local Budget Revenues and Expenditures (APBD)

Instruments of authority include:
Governor Decree.
Governor Regulation.

<p>Jembrana</p> <ul style="list-style-type: none"> • Public Works Agency • Forestry Division on Marine, Forestry and Fishery Agency • Agricultural Division on Agriculture, Plantation and Animal Husbandry Agency • Plantation Division on Agriculture, Plantation and Animal Husbandry Agency • Animal Husbandry Division on Agriculture, Plantation and Animal Husbandry Agency 	<p>Regency or District / Kabupaten</p>	<p>A directly elected Governor is head of the provinces. Each individual agency is headed by an appointed Head of Local Agency and division is headed by an appointed Head of Local Division</p> <p>Funding:</p> <ul style="list-style-type: none"> - Ministry of National Development and Planning (BAPPENAS) called general allocation budget /Dana Alokasi Umum (DAU) and special allocation budget (DAK) - Development Planning Agency at Sub-National Level (BAPPEDA) called Local Budget Revenues and Expenditures (APBD) <p>Instruments of authority include: Regent Regulation</p>
<p>Melaya</p>	<p>Sub-district / Kecamatan</p>	<p>A directly elected Head of Sub-district or Camat is head of the Sub-district.</p> <p>Funding</p> <ul style="list-style-type: none"> - Ministry of National Development and Planning (BAPPENAS) called sub-district allocation budget/Alokasi Dana Kecamatan (ADK) - Development Planning Agency at Sub-National Level

		(BAPPEDA) called Local Budget Revenues and Expenditures (APBD)
		Instruments of authority include: Part of local government regulation in regency and sub-district level
Tukadaya	Village / Desa	A directly elected Head of Village is head of the village.
		Funding: <ul style="list-style-type: none"> - Ministry of National Development and Planning (BAPPENAS) called village allocation budget / Alokasi Dana Desa (ADD) - Development Planning Agency at Sub-National Level (BAPPEDA) called Local Budget Revenues and Expenditures (APBD) - Badan Usaha Milik Desa (village-owned enterprise)
		Instruments of authority include: Village decree, village regulation
Banjar Munduk Ranti, Pangkung Jajang, Sarikuning, Sarikuning Tulung Agung, Berawantangi, Berawantangi Taman, Sombang and Kembang Sari	Community / Banjar	A directly elected Head of the Sub-village or Kelian Banjar is head of the community / Banjar
		Funding: Village budget
		Instruments of authority include: Awig-awid desa adat (a traditional policy of local customary practices and tradition as villager obligation)
Subak Sawah Subak Sawah Sari kuning, Subak Sawah Pangkung jajang, Subak Sawah Berawantangi, Subak Sawah Sombang and Subak Sawah Pangkung jaka	Subak Sawah	A Head of Subak or Kelian Subak is head of the Subak Sawah
		Funding: Bali Provincial Government budget
		Instruments of authority include: Awig-awid desa adat
Subak Abian Subak Abian Giri Sari, Subak Abian Udiana Sari, Subak Abian Bina Karya, Subak Abian Sari Karya,	Subak Abian	A Head of Subak Abian or Kelian Subak Abian is head of the Subak Abian

Subak Abian Santhi Phala, and
Subak Abian Sila Krama

Funding: Independent, depends on
their own production

Instruments of authority include:
Awig-awid desa adat

1.4 The Innovation System map

As noted in Section 1.3.1, the value chain for biogas cooking fuel is a particular area of early focus in the case study. For this reason, we have developed an initial innovation system map, as presented in figure 2. This includes the market chain, adapted from stakeholders' input outlined in Section 4 of Local Biogas in Indonesia Report, placed in the context of the policy and business environments affecting its development. Arrows link the concepts across the market chain and policy and business environments, with the dotted lines denoting institutional links and the green solid lines financial flows.

Looking into details in market chain, the input for feedstock could be crop waste and/or animal waste from crop and livestock farms, represented in the diagram as crop and livestock farmers. Waste is then collected and undergoes biological and chemical pre-treatment before going to the biodigester, in order to optimise the chemical conditions for methanogenic bacteria. After this comes anaerobic digestion and biogas production. Biogas is distributed through pipelines, which are connected to stoves. The actors who contribute to the processes could be farmers, cooperative locals, small business or state owned bodies, although those actors remain ambiguous in the diagram (Cornish, 2016). Full connections between market chain, policy and business sector can be seen in figure 2.

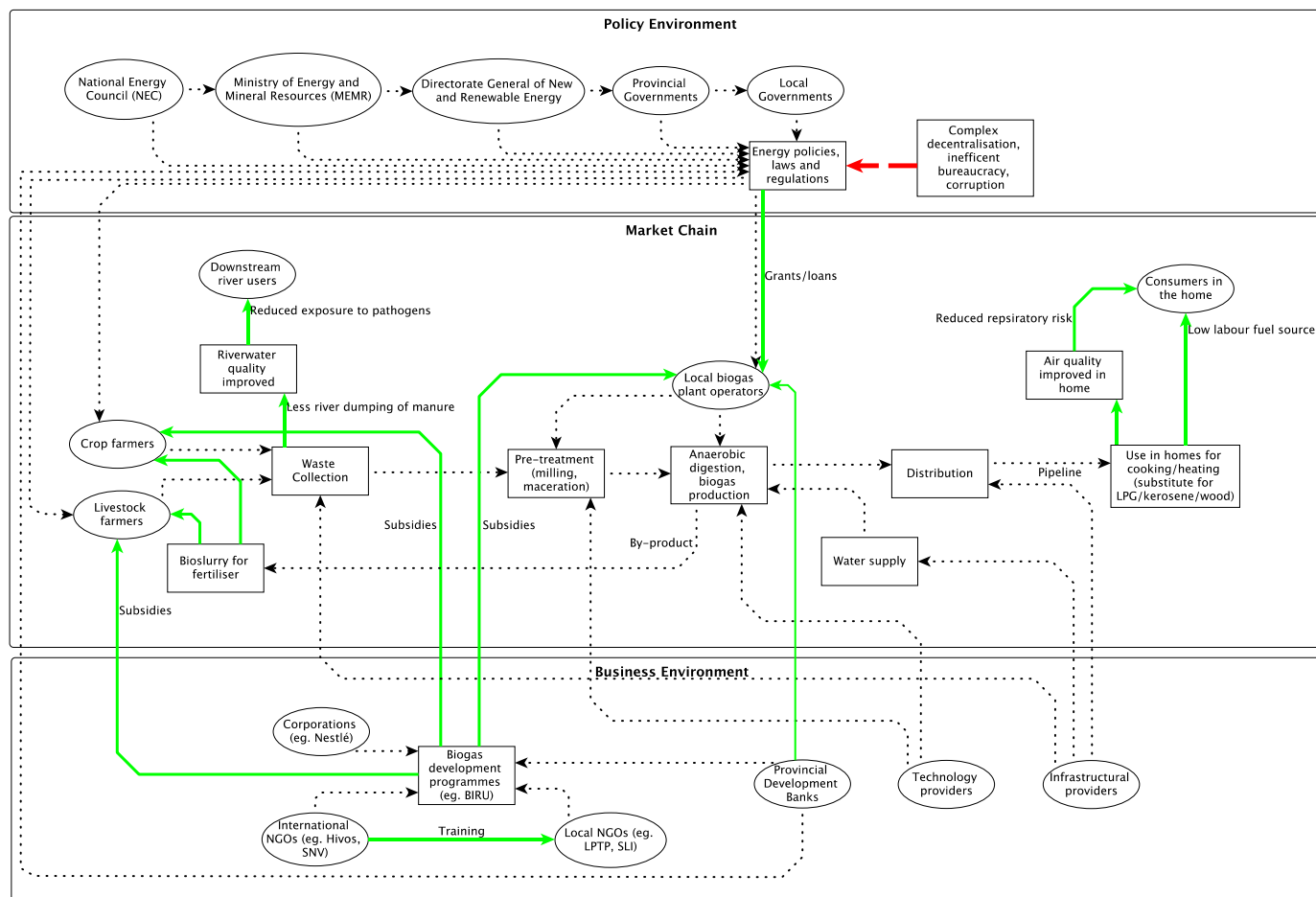


Figure 2 Draft innovation system map for the value chain for biogas cooking fuel

1.5 Stakeholder engagement

Stakeholder engagement is important, particularly for a research project. Any societal issue is usually defined differently by different people. Only by ensuring that as many voices as possible are heard can a research project discover blind spots and uncover creative, but underrepresented, solutions. Moreover, regular consultation with stakeholders ensures that particular regulations or development plans are well communicated and coordinated. In this regard, it is particularly important to develop a relationship between government officials, private sector stakeholders, local communities and academics. The first Indonesian case study workshop was held in Bali on 11-13 May 2016. The workshop was well attended, with more than 68 registered participants from backgrounds such as local and national government, private sector, NGOs, academia, science and international experts (Takama et al., 2016).

A full workshop summary has been prepared and circulated to participants, and an overview brief is appended to this report as Appendix A.

The main objective of the workshop was to bring participants from many backgrounds and sectors together in order to discuss the potential of several forms of bioenergy in Indonesia and pathways for their development. Moreover, participants explored risks and opportunities of these pathways, as well as potential co-benefits such as sustainable economic growth. The workshop was organised by Udayana University, Stockholm Environment Institute (SEI) and PT. Sustainability and Resilience Co (su-re.co) within the framework of two research projects funded by the European Commission: GreenWin and TRANSrisk. The event further benefited from the generous support from the Climate Change Trust Fund (ICCTF) on behalf of Ministry of National Development Planning (BAPPENAS).

The first day of the workshop allowed for a field trip to the village of Tukadaya in the Jembrana regency of West-Bali. There, participants were given the opportunity to see and discuss successful pilot bioenergy projects, i.e. cooking stoves using wood pellets and digesters processing animal waste into biogas for the village community. This allowed participants to gain valuable insights on how rural communities could benefit from bioenergy developments, and delivered a solid base for the fruitful discussions that took place over the following two days.

The second day began with a variety of presentations from the research community in Indonesia, governmental officials and locals as well as international experts on bioenergy. These presentations supplemented the first hand experiences of the first day field trip with some insights from other countries and policy developments in Indonesia itself. Later on that day, participants were split into four groups and discussed their vision of bioenergy

development in East Java and Bali, how they could contribute to governmental policies of reducing GHG emissions and the associated risks and opportunities. Furthermore, the groups were invited to discuss what kinds of feedstocks were deemed particularly beneficial for exploitation in order to increase bioenergy uptake in Indonesia.

The exercises on the third day were built on the fruitful discussions and findings from day two and invited the participants to analyse the value chains for certain feedstocks and to identify issues along the value chain which could hinder a successful bioenergy development. Again, four groups were formed according to the participants' backgrounds and knowledge. The value chains discussed during this session were wood pellets, biogas and bioethanol from rice straw, rice husks and other agricultural and household residues.

The stakeholder engagement table in table 6 includes a list of all stakeholders contacted to date, the majority of whom were attendees at the first case study workshop.

Table 6 Stakeholder Engagement

Type of stakeholder	Position in the organisation*	Economic sector**	Type of engagement***	Month and year contacted
1. Professor	Research	Environment	Workshop	May 2016
2. Dissemination	Research	Environment	Workshop	May 2016
3. Researcher	Research	Environment	Workshop	May 2016
4. Researcher	Research	Environment	Workshop	May 2016
5. Researcher	Research	Environment	Workshop	May 2016
6. Project Manager	Research	Environment	Workshop	May 2016
7. Lecturer	Research	Academic	Workshop	May 2016
8. Lecturer	Research	Academic	Workshop	May 2016
9. Lecturer	Research	Academic	Workshop	May 2016
10. Lecturer	Research	Academic	Workshop	May 2016
11. Vice Rector IV	Research	Academic	Workshop	May 2016
12. Magister student	Research	Academic	Workshop	May 2016
13. Magister student	Research	Academic	Workshop	May 2016
14. Executive Director	Business	Environment	Workshop	May 2016
15. Energy coordinator	Business	Environment	Workshop	May 2016
16. Deputy Program	Business	Environment	Workshop	May 2016
17. Deputy Finance	Business	Environment	Workshop	May 2016
18. Administrator	Business	Environment	Workshop	May 2016
19. PME Manager	Business	Environment	Workshop	May 2016
20. RCCCU representative	Business	Environment	Workshop	May 2016
21. Civil-IESR representative	Business	Environment	Workshop	May 2016

22. CEO	Research consultancy	/	Environment	Workshop	May 2016
23. Researcher	Research consultancy	/	Environment	Workshop	May 2016
24. Research Assistant	Research consultancy	/	Environment	Workshop	May 2016
25. Research Assistant	Research consultancy	/	Environment	Workshop	May 2016
26. Intern	Research consultancy	/	Environment	Workshop	May 2016
27. Intern	Research consultancy	/	Environment	Workshop	May 2016
28. Office Manager	Research consultancy	/	Environment	Workshop	May 2016
29. Interpreter	Research consultancy	/	Environment	Workshop	May 2016
30. Headman of village	Farmer		Agriculture	Workshop	May 2016
31. Minimoto stove, wood pellet user	Farmer		Agriculture	Workshop	May 2016
32. Minimoto stove, wood pellet user	Farmer		Agriculture	Workshop	May 2016
33. Head of farmer community	Farmer		Agriculture	Workshop	May 2016
34. Head of farmer community	Farmer		Agriculture	Workshop	May 2016
35. Head of farmer community	Farmer		Agriculture	Workshop	May 2016
36. Head of sub village	Farmer		Agriculture	Workshop	May 2016
37. Head of farmer community	Farmer		Agriculture	Workshop	May 2016
38. Head of farmer community	Farmer		Agriculture	Workshop	May 2016
39. Head of sub village	Farmer		Agriculture	Workshop	May 2016
40. Vice	Farmer		Agriculture	Workshop	May 2016
41. Treasury	Farmer		Agriculture	Workshop	May 2016
42. Head of farmer community	Farmer		Agriculture	Workshop	May 2016
43. Head of farmer community	Farmer		Agriculture	Workshop	May 2016
44. Head of sub village	Farmer		Agriculture	Workshop	May 2016
45. Vice	Farmer		Agriculture	Workshop	May 2016

46. Head of Climate Change Department	Government	Environment	Workshop	May 2016
47. Senior Staff	Government	Forestry	Workshop	May 2016
48. Staff	Government	Technology	Workshop	May 2016
49. Director of Bioenergy	Government	Energy	Workshop	May 2016
50. Climate Change Department Manager	Business	Environment	Workshop	May 2016
51. Manager	Business	Environment	Workshop	May 2016
52. Environment Department Manager	Business	Environment	Workshop	May 2016
53. Operational Manager	Business	Environment	Workshop	May 2016
54. General Manager	Business	Environment	Workshop	May 2016
55. Quality installation technician	Business	Energy	Workshop	May 2016
56. Executive director	Business	Energy	Workshop	May 2016
57. Technology and Product Development Manager - Gas Directorate	Government	Energy	Workshop	May 2016
58. Project Manager	Business	Energy	Workshop	May 2016
59. CEO	Business	Energy	Workshop	May 2016
60. Operational Manager	Business	Energy	Workshop	May 2016
61. Finance Manager	Business	Energy	Workshop	May 2016
62. Lawyer	Business	Legal	Workshop	May 2016
63. Manager	Business	Economy	Workshop	May 2016
64. General Manager	Business	Economy	Workshop	May 2016
65. CEO	Business	Energy	Workshop	May 2016
66. Operational Manager	Business	Energy	Workshop	May 2016
67. Project Manager in Bali Provincial Agriculture Agency	Government	Agriculture	Workshop	October 2016
68. Quality installation technician	Business	Energy	Workshop	October 2016
69. CPO/Partner Organisation	Business	Energy	Workshop	October 2016
70. Founder and CEO	Business	Environment	Workshop	October 2016
71. Head of Spatial, Mining and Energy Department in	Government	Energy	Workshop	October 2016

Jembrana Public Works Agency				
72. Senior lecturer	Research	Academic	Workshop	October 2016
73. Director of Centre of Excellence Community Based Renewable Energy	Research	Energy	Workshop	October 2016
74. Intern Researcher	Business	Energy	Workshop	October 2016
75. Secretary	Research	Energy	Workshop	October 2016
76. Organisation Manager	Research	Energy	Workshop	October 2016
77. Finance Manager	Research	Energy	Workshop	October 2016
78. Environment Aspect Manager	Research	Energy	Workshop	October 2016
79. Law/Legal Aspect Manager	Research	Energy	Workshop	October 2016
80. Economic Aspect Manager	Research	Energy	Workshop	October 2016
81. ICT Manager	Research	Energy	Workshop	October 2016
82. Researcher	Research	Environment	Workshop	October 2016
83. Researcher	Research	Academic	Workshop	October 2016
84. Researcher	Research	Academic	Workshop	October 2016
85. Researcher	Research	Academic	Workshop	October 2016

* Government (national / subnational), research / consultancy, business, other (specify)

** Energy, Industry, transport, environment, agriculture / forest, financial / trader, other (specify)

*** Interview, focus group, workshop, survey etc.

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Appendix A - Summary of First Case Study Workshop, Bali, May 2016

Sustainability and Resilience of Bioenergy for Climate Change in Bali and East Java: Scoping and Envisioning

Auditya Sari^{1,3}, Cynthia Juwita¹, Stefan Bößner², Timothy Suljada²
Ibnu Budiman^{1,3}, Francis X. Johnson², Ida Ayu Giriantari³, Made Suastra³
Takeshi Takama^{1,2,3}, Erwin Widodo⁴
¹PT. Sustainable and Resilience Co, Bali
²Stockholm Environment Institute
³Udayana University, Bali
⁴Ministry of National Development of Republic Indonesia

Introduction

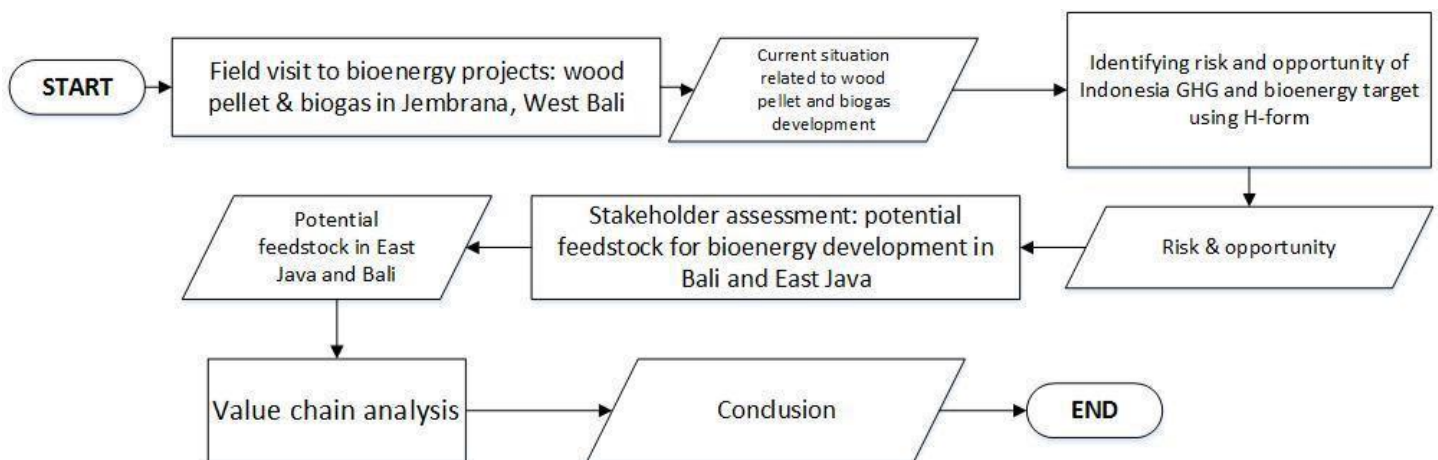
To accelerate bioenergy utilization in Indonesia, a preliminary study has been conducted where Bali and East Java were selected. Udayana University, Stockholm Environment Institute and PT Sustainability and Resilience Co (su-re.co) within the framework of two research projects funded by the European Commission: GreenWin and TransRISK organized an international workshop on sustainability and resilience of bioenergy for climate change. The event furthermore benefited from the generous support of the Indonesia Climate Change Trust Fund (ICCTF) on behalf of Ministry of National Development Planning (BAPPENAS) of Republic Indonesia. It took place in Bali, on 11-13th May 2016, attended by 68 registered participants coming from background, local and national government, private sectors, non-government organizations (NGOs), academics, scientists and international experts.

Data were collected during field visits and focus group discussion (FGD) between stakeholders from different backgrounds and sectors, by discussing the potential for bioenergy development in Bali and East Java. Several qualitative tools such as H-form exercises have been

used by the participants to analyze the risks and opportunities of bioenergy development pathways as well as potential co-benefits such as sustainable livelihoods and economic growth through green business possibilities with both climate change adaptation and mitigation benefits. Value chain analysis was also used to identify production processes for preferred bioenergy options available in Bali and East Java and the systemic barriers and enablers for their implementation. The workshop developed and shared ideas creating green business models, investment opportunities, and partnership on energy poverty eradication and resilient livelihood with bio-energy. The workshop also engaged the assessment of stakeholder network with climate change adaptation and mitigation pathways.

Improved sustainability assessment of bioenergy and on-the-ground evaluations are needed to guide priority setting for adaptation and mitigation of climate change with bioenergy in Bali and East Java.

Methodology



Result and Discussion

As mentioned before, in order to view the potential of bioenergy development in East Java and Bali, a participatory appraisal using several tools, namely H-form, stakeholder assessment, value chain matrix and matrix of change analysis through focus group discussion (FGD) was conducted. Following that, a set of result contains the recommendations and insights regarding bioenergy development are presented as below.

1. Potential Feedstock and technologies for bioenergy development in East Java and Bali

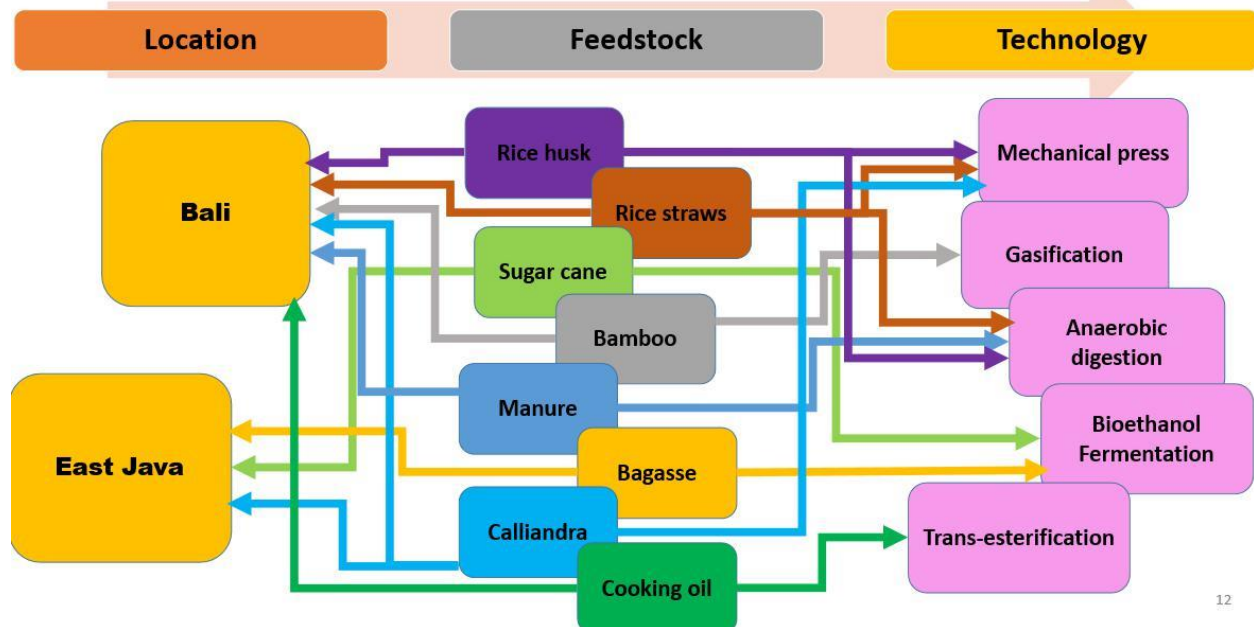


Figure 1. Map of potential feedstock and the common technologies for bioenergy development in East Java and Bali.

After the discussion among participants, it can be concluded that Bali has potential bioenergy feedstock which are rice husk, rice straws, sugarcane, bamboo, manure, caliandra. Meanwhile, bagasse, caliandra and cooking oil are potential to be developed in East Java. The common technologies for bioenergy development in Indonesia include mechanical press for wood production, gasification, anaerobic digestion, bioethanol fermentation and biodiesel trans-esterification.

2. Risk and Opportunity of Bioenergy Development in East Java and Bali

Blending mandates on bioenergy usage drive the market opportunity for bioenergy usage. Indonesia has a large potential for the use of agricultural residues for bioenergy production. However, those opportunities come with risks. Government support could be both a risk and an opportunity for bioenergy development in East Java and Bali. Government's mandate for protecting the environment and the responsibility for conservation creates some opportunity for collaboration with bioenergy producers. However, unstable political power in the government affects the policy consistency since sanctioned regulation is needed to secure the investment on bioenergy. Bioenergy producers and investors have also been burdened by a number of domestic factors that make it difficult to purchase or rent land for agricultural developments – complicated application and permit processes, and land tenure issues. While the government has attempted to provide legislation that supports bioenergy feedstock development in recent years, complicated application processes prolong plantation development processes making them costly and complicated. Nevertheless, corrupt practices still allow plantation companies to fast track bureaucratic hurdles and sidetrack community consent procedures which add further unexpected costs.

A wide range of conversion technologies is used for bioenergy production in the East Java and Bali. Most projects are still in a start-up phase, at different levels of commercialization and deployment. However, there are lots of opportunity for bioenergy development related funding. For example, government supported programs grant credit access at preferential rates to develop feedstock plantations. The private companies are usually allowed to act as partners to local farmers, applying for credit and subsequently connecting those funds to farmer group. Poor infrastructure and insufficient access to technology is also slowing bioenergy development. An important obstacle to bioenergy distribution is the cost and risks of transportation and logistics in moving equipment and products from and to rural areas; or transporting from fields to main gathering points or end-user facilities. For example, Bali in particular, damaged roads and unpaved roads are common causing regularly slow and expensive land transportation.

3. Challenges for bioenergy development in East Java and Bali

a. Rice husks and rice straws to biomass and wood pellet

Based on the discussion among the participants, the value chain for this process was amended, respectively, to land and soil management, seeding, plantation maintenance, plant disease protection, pesticide and fungicide, harvesting, transportation, drying, storage, re-drying, milling, pellet factory and end users. Each step faces specific issues to be resolved in order to support bioenergy development. The main problem is institutional support from local government to develop biomass programmes. Other problems are technologies (drying and storage) and financial support. Rice residuals can be converted into biomass pellets; however, issues stated above need to be resolved beforehand. The community also has to be provided with stoves to use the pellets. The pellet factory should be built in the village to enable the biomass production efficient.

b. Rice husks, rice straws and manure to biogas in small scale

Just as for wood pellet production, the value chain consists of plantation, feedstock production, collection, processing, production, distribution and end users. The amount of rice straws and husks was viewed as insufficient for producing biogas. It was agreed that animal manure is also required in order for the process to function. Changes of land use in Bali becomes an issue for the biogas development, as farmers tend to sell their land for business development. It also affects the decreasing number of farmers, especially planters who would be needed to labor in the rice fields. It is important to note that some installed biogas digesters are not functioning, mainly due to lack of technological maintenance. This issue needs to be taken into account by all stakeholders - not only by the government, but, also third parties such as NGOs and private businesses. Apart from those issues, the most serious challenges to biogas development in Indonesia were identified as lack of financial support, technology approach and the certainty that these will be delivered to the farmers who need them most. Nevertheless, awareness and behavior are still important challenges.

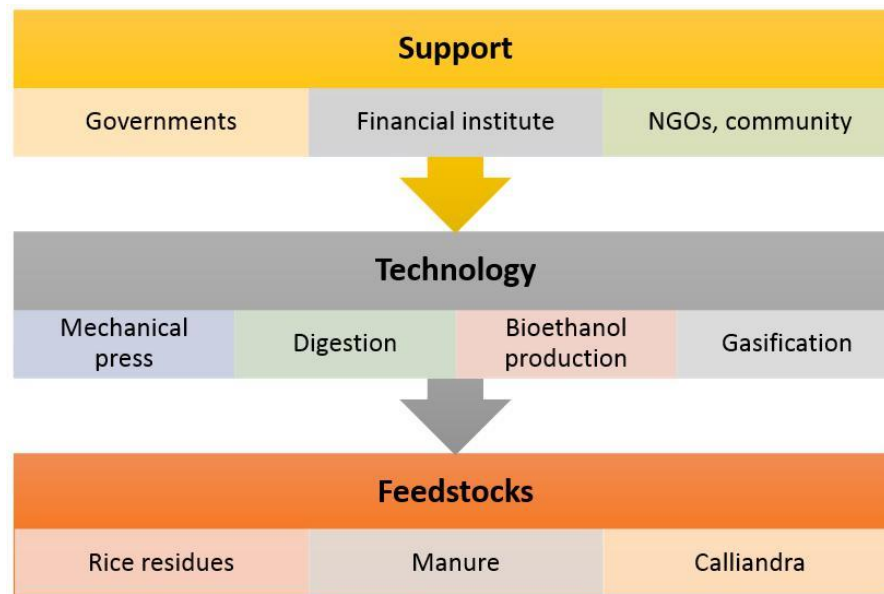
c. Rice straws and husks for large scale biogas production

For this process, in addition to the value chain described for the small scale biogas production, location is added to be an aspect that must be considered, especially in Bali due to high investment costs. Furthermore, it is believed that large scale biogas production from rice residues did not look promising due to issues related to the economic viability. Fertilizer usage was mentioned as a more realistic use for those rice residues because rice residues still require manure in order to maximize the yield. The participants also voiced their opinions that the technology was not really suitable and difficult to transfer from abroad to Indonesia. Moreover, participants evoked the lack of social acceptance of biogas installations by the community because of low incentives or direct benefits for the community.

d. Rice residues, bagasse, and Napier grass for bioethanol

Overall, the group came to the conclusion that the main obstacles for successful bioethanol development arose in the production and end users stage. An example with regards to user concern, one bioethanol producer among the participants rejected distribution of bioethanol-blended fuel at the same price as standard gasoline because it would not cover costs. Therefore, the main obstacle for the development of bioethanol is the lack of government commitment on subsidies or the regulation of the market price. It was clearly discussed among participants that the responsibility lies with the government, to provide support by giving incentives to bioethanol companies. Furthermore, the end users were attributed a high difficulties score since the group assumed that they were unwilling to pay higher prices for bioethanol.

Conclusion



Based on the analysis, it can be concluded that rice husks, bagasse, rice straws and manure are the potential feedstock for bioenergy development in East Java and Bali. Following that, mechanical press, digestion, gasification, and fermentation for bioethanol production are the common technologies developed in Indonesia. However, there are still a set of issues that has to be resolved in order to achieve the target of bioenergy set by the Indonesian Government. The common issues faced in bioenergy development are inadequate financial and government support, lack of knowledge and skillful human resources, costly investment, and lack of social acceptance. To overcome these issues, full support from all levels of government (national, regional, local), funding institution i.e. bank, NGOs and local community are required.

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