CHAPTER 14

Ensuring monetary, human capital and natural capital returns in biomass production

Lessons from the Mentawai biomass gasification power plant project

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Abstract: Primary energy demand in Indonesia is growing rapidly due to urbanization, economic development and population growth. The Government of Indonesia has mandated that new and renewable energy should contribute 23% of the national energy mix by 2025. Indonesia's updated Nationally Determined Contribution (NDC) stresses five sectors in which greenhouse gas (GHG) emissions are to be reduced, with land use, land use change and forestry (LULUCF) and energy being the highest priorities. While Indonesia is committed to addressing climate change through the LULUCF sector, there are clear contextual challenges that must be confronted to create the enabling conditions for REDD+, the main mechanism for carbon revenues, to contribute to landscape restoration in Indonesia. This chapter argues that biomass production for power plants in remote and isolated areas could become an additional agent of change in tackling this difficult problem. Using a case study from the Mentawai islands in Indonesia, we describe a methodology for rural electrification using a community- and biomass-based power generation system. The Mentawai model not only shows that biomass power plants can be used as the backbone for electricity generation in remote and isolated settings, but it can also be valuable tools to help alleviate poverty in underdeveloped regions in Indonesia as well as help finance the restoration of degraded and marginal lands. Replicating this system—one which results in biomass production, land restoration, affordable electricity and local economic growth—could improve the contribution of renewable energy to the energy mix and to the overall prosperity of Indonesians in rural and remote areas.

Keywords: rural electrification, biomass power plant, community based biomass production, ecosystem restoration, economic empowerment
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14.1 Introduction

Promoting renewable energy in Indonesia requires extraordinary effort because many of the islands across the entire country do not have reliable grids. This condition makes island grids mostly dependent on diesel-powered generators that provide power on demand amongst islands. Based on the National Electrification Ratio, Indonesia has successfully connected 97.5% of households to the electricity grid (ESDM 2019). However, efforts to achieve universal electricity access continue to prove difficult, especially for people living in small islands, those far inside dense forests, or those isolated from major human settlements (BPS 2013).

One of the main limitations of diesel-powered generators in remote areas is the costly operational expenses involved. Delayed fuel shipments due to bad infrastructure and unpredictable weather can cause these generators to run out of fuel (ESDM 2017). Yet increasing the use of renewable energy in such areas can be similarly challenging; applying solar and wind energy is difficult, for instance, due to their intermittency (Pérez-Arriaga and Batlle 2010; Ren et al. 2017). Additional high-cost infrastructure, such as batteries, liquid energy storage, and other forms of storage, are necessary to close the gap. Thus, the investment cost of renewable energy could be considerably higher than the renewable energy investment in other countries where higher capacity in one site is much more common. Indonesia's state-owned electricity company (PT PLN) has considered using a hybrid scheme with diesel power plants, in which renewable energy-based power plants act as the main power source, and diesel plants maintain base power supply and overcome the intermittent behaviour of renewable energy (Brahim 2019). However, this scheme is difficult to implement as diesel power plants still require reliable fuel supplies from other islands.

On the other hand, some renewable energy resources promise characteristics of continuous and stable electricity supply owing to their perpetual sources of energy (Shin et al. 2019). Hydro, geothermal and biomass are among such sources of renewable energy in Indonesia (IRENA 2017). Continuous load renewable energy is crucial in the development of archipelagic regions due to their capability to supply base load independently without additional hybrid connection using fossil energy. However, some renewable energy sources have obstacles related to development in small islands.

Hydropower derives from the energy that is produced when water moves from higher to lower elevations (Didik et al. 2016; Erinofiardi et al. 2016). This requirement is inconvenient on many islands as rivers are short and water levels fluctuate between seasons. Furthermore, some rivers are located remotely from the center of demand, which causes significant energy loss when energy is transferred to these areas. A similar challenge occurs with geothermal power (WWF 2012; Semedi et al. 2018; Ibrohim et al. 2019), where not every island has geothermal resources beneath the Earth's crust, particularly in Indonesia where most geothermal sources are located in the mountains. Long transmission is crucial, yet simultaneously inefficient due to energy loss. Additionally, geothermal power plants are often unsuitable for small islands. This is because the high investment cost necessitates a high capacity, which makes it inefficient to use the power only for small-scale mini grids.

Local biomass, on the other hand, can be utilized to create small-scale power plants that can be placed near centres of demand on small islands in Indonesia. Biomass resources consist of many different materials, including residual forestry waste, planted woody and non-woody biomass, animal residue, sewage and municipal solid waste (Liu et al. 2019; Perea-Moreno et al. 2019). Due to its conducive climate and soils, Indonesia has huge potential as a biomass producer, including its small island regions. Biomass can be produced locally and in the vicinity of a power plant, making such plants manageable in almost every area near a center of electricity demand (Shin et al. 2019).

This chapter describes a system of using small-scale biomass gasification as a solution for small-scale power plants in small islands in Indonesia.[1] As opposed to direct combustion of biomass combined with steam turbines, small-scale gasification processes are technically mature and behave similarly to diesel-powered generators. Gasification technology has lower emissions of NOx and SOx, more efficient heat, and fewer requirements for consumables. It is widely reported that gasification is appropriate for small-scale capacities from 10 kWe up to 1 MWe. Therefore, small-scale biomass gasification is preferable for the electrification of small islands because of its capacity to utilize local biomass resources and its ability to provide reasonable cost electricity, as no energy storage is required for such systems (Sonal 2009).

In the system, biomass is purchased directly from local communities, thus supporting local economic growth. Moreover, the system would support land restoration efforts, as to a significant extent, biomass planting areas would be selected to maintain land stability, restore degraded land and sequester CO_2. This chapter also identifies the use of REDD+ payments to enhance funds needed for land restoration with bamboo or other perennial plants, which could be used to produce feedstock for small-scale biomass gasification power plants.

This chapter highlights the proof of concept of the system developed in Mentawai Islands District in West Sumatra, Indonesia. At only 29.8%, the electrification ratio in the Mentawai islands is significantly lower than the national average of 97%. The district has power plants in three isolated villages: Madobag (300 kW), Matotonan (150 kW) and Saliguma (250 kW). These power plants run on local forest biomass, particularly bamboo. Owing to its capability to reinforce degraded land and intercropping behaviour, and its high calorific value, bamboo is planted on a large scale in the Mentawai islands in villager-managed social forestry schemes. This strategy in the Mentawai region serves as a proven model

1 Gasification is a process in which solid biomass is converted into combustible gases.

for replication of small-scale biomass gasification power plants on other islands with low electrification ratios.
The contributions of this chapter, therefore, are as follows:

- A methodology is provided for renewable energy-based rural electrification in Indonesia, which covers the social, economic and political aspects of electrification.
- A business model is highlighted, whereby rural electrification and employment creation are carried out simultaneously, promoting sustainable development of rural areas. The business model further shows that community biomass-based power plants could receive enhanced funding through carbon credit schemes.

The rest of the chapter is organized as follows: Section 2 elaborates on the problem description and the methodology applied. Section 3 reviews socioeconomic conditions in the Mentawai Islands prior to the biomass gasification project. Section 4 focuses on biomass gasification project implementation in the Mentawai islands, and is followed by a conclusion in Section 5.

14.2 Original problem description and methodology applied

14.2.1 Original problem description in the Mentawai islands

By surveying the needs of locals in the Mentawai islands, we identified several problems in bringing reliable electricity to communities. By holding public consultations with various stakeholders in the island district, we then formulated a solution that satisfied the following conditions:

(C.1) The energy source is renewable and can be obtained locally;
(C.2) The harvesting process of the energy source has a minimal impact on the ecological system, and must involve reforestation efforts;
(C.3) The generation system must be dispatchable and scalable;
(C.4) The electricity produced must be equitable, reliable and affordable.

The first point in condition (C.1) was mandatory to support the Government of Indonesia's plan for renewable energy to contribute 23% of the national energy mix by 2025. The second point under (C.1) was intended to tackle two things: (1) to minimize raw material costs, and (2) to create local employment, which in turn would boost the local economy. These could be achieved with the intended solution, as it would result in lower electricity generation costs, thus making electricity more affordable, while simultaneously fostering local employment in support of sustainable development. Overall, this meant that communities could afford to purchase the electricity since they would have an earnings source (due to increased employment), and the electrification would be sustained since people would purchase the power generated.

The specificity of (C.2) strengthened the first point under condition (C.1) by clarifying what renewable energy sources were most appropriate for sustainable development. Suppose the energy source was renewable, but harmed the ecological system in other ways: for instance, solar-based power which required deforestation for the installation of solar panels, then deforestation would increase the reflectivity of the land surface and evapotranspiration, and would also cause consistent warming, meaning the ecological benefits of using the renewable energy source would be negated, at least partially. Reforestation efforts were aligned with the Government of Indonesia's NDC and, in addition, would enable REDD+ conditions which could only be paid as a result of reducing deforestation and land degradation.

The first point under condition (C.3), dispatchability, was mandatory for power generation. Meanwhile, the second point under (C.3), scalability of power generation, was required since the electrification was meant for rural areas where the population is distributed unevenly due to geographical conditions, but electrification could also drive industrial growth in those areas, which could possibly create greater energy demand in the future.

Condition (C.4) regarding equitability, reliability and affordability was primarily affected by the business and political circumstances surrounding power generation. Electrification in rural areas greatly depends on funding, and the management of funds involves the central government, local government and the private sector. Equitability meant that the electricity produced must benefit all community members living in the respective villages. This way, all village people would support the electrification programme and consequently it would be more sustainable, both financially and economically. Reliability meant that the electricity produced must be resilient to any changes in economic, social or political circumstances. Lastly, affordability meant that rural communities would be able to purchase electricity without having to sacrifice their primary needs.

Conditions (C.1) to (C.4) ensured the workability and sustainability of the rural electrification. REDD+ conditions alone were not sufficient to make the whole development workable and sustainable; indeed, there were economic, social and political aspects that also had to be considered. Economically, REDD+ actions are expected to increase carbon stock in addition to other major functions in forestry (Ricard et al. 2011). Carbon emissions reductions are supposed to be credited and incentivized through community-based schemes. Socially, harmonization with other relevant sectors, such as agriculture, water resources and energy, was also important to reduce potential future conflict. Conciliation with small and medium communities, such as schools, hospitals and wood consuming companies, is also crucial to promote REDD+ actions. Politically, it was important to link with national renewal energy initiatives and strategies in regional and national policies, as institutional frameworks or environmental programmes are also essential for implementing REDD+ actions (Ricard et al. 2011).

14.2.2 Methodologies applied

Methodologies were formulated so results achieved in Mentawai Islands District could be replicated in other rural areas. The formulation consists of seven methodologies:

(M.1) Determine the rural area to be electrified

A rural area prioritized for electrification should be an area with a low electrification ratio. It should also be an area the government intends to electrify. Such areas are commonly referred to as 3T (*Terdepan, Terpencil dan Tertinggal*) areas, meaning frontline, isolated underdeveloped areas. If the chosen area aligns with government plans, then relatively speaking, political barriers should be fewer. According to Indonesia's Ministry of National Development Planning (Bappenas 2019), there are 52 3T areas in Indonesia that require electrification with a capacities of 5 to 10 MW.

(M.2) Selection of renewable energy source

The renewable energy source must be selected to comply with conditions (C.1), (C.2) and (C3). Therefore, the only suitable renewable energy source that can be obtained through reforestation is biomass, such as bamboo (Darabant et al. 2014; Sharma et al. 2018; Yoesgiantoro et al. 2019). Solar energy can meet criteria (C1) and (C2), but not (C3), as solar PV plants can only generate power when the sun is shining. Battery storage can be added, but this solution would have a minimal social and economic impact in providing employment in local communities, which would ultimately have to rely on government subsidies. In contrast, by sourcing feedstock from surrounding communities, biomass power plants can increase local capacity to afford electricity.

(M.3) Establishment of a business model

A business model must be established before any engagement with other stakeholders. In addition, the business model must facilitate the following:

- local employment creation, which will focus on employing rural women and youth;
- equitable electricity generation, in which the biomass will be sourced exclusively from local biomass producers;
- sustainable electrification, which will be guaranteed by PLN as sole off taker of electricity produced by biomass power plants.

Figure 1 shows the intended business model where Indonesia's Environment Fund Management Agency or *Badan Pengelola Dana Lingkungan Hidup* (BPDLH) interacts with the local community, the independent power producer (IPP) and state-owned electricity company *Perusahaan Listrik Negara* (PLN). A Power Purchasing Agreement (PPA) with

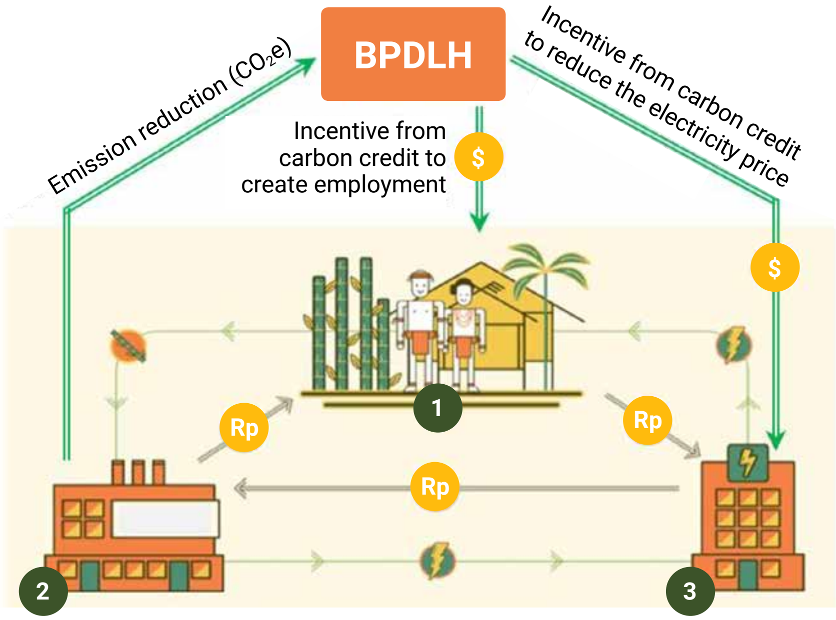

Figure 1. The proposed business model for rural electrification in Indonesia: (1) represents the local community; (2) represents the IPP; and (3) represents state-owned electricity company, PLN

PLN for a duration of 20–25 years is the one single factor making a biomass power plant project bankable in the eyes of investors and lenders. Once a project is bankable, it can easily be put out for tender. An open and high-quality tender process will then ensure the budget and schedule for completion of the project can be predicted with relative accuracy.

The other important party in the scheme is BPDLH, a newly formed non-structural entity under the Ministry of Finance created to manage funds for environmental protection and management, including climate change mitigation and adaptation efforts. The regulatory framework for BPDLH provides a solid legal basis for a robust and flexible vehicle to fund activities in the public interest, including managing money from international donors. Under the scheme, a local community would plant biomass and sell it to an IPP, which would then generate electricity for sale to PLN, which, in turn would sell the electricity to the local community. Since the electrification process would involve reforestation, such a system may be entitled to REDD+ incentives managed by BPDLH. Accordingly, this chapter suggests that carbon credit payments be used to enhance employment opportunities and reducing electricity prices in the long term.

To the best of the authors' knowledge, the business model in Figure 1 is the first model that connects preservation of the environment with employment creation and rural electrification. Even without carbon credit payments, the interaction between (1), (2) and (3) in Figure 1 would guarantee sustainable electrification. However, the addition of carbon credit payments would facilitate faster development in rural areas, and would also provide sustainable electrification as a result of the low prices paid for electricity. Ultimately, carbon credits could be used to cover the capital expenditure for initiating the development of a rural electrification project.

(M.4) Secure an MoU with the local branch of PLN

In Indonesia, PLN is the official entity that can sell electricity to the public. Therefore, PLN must be involved in any rural electrification plan for a rural area. The local PLN must be convinced to purchase the electricity produced by the IPP so that the business model in Figure 1 can be implemented.

(M.5) Feasibility study

A feasibility study must be carried out to predict the economic value of electrification. The result from this study could be used as justification for the electrification plan at both social and political levels.

(M.6) Securing funds for development

One of the reasons that Indonesia still has many areas with a low electrification ratio is the lack of funding. By conforming to conditions (C.1) to (C.4), a rural electrification plan would be entitled to financing from the Environment Fund managed by BPDLH (Setkab 2019). BPDLH is the national agency that manages funds relating to forestry, energy and mineral resources, carbon trading, environmental services, industry, transportation, agriculture, marine and fisheries and other fields related to the environment. The sources of funds managed by BPDLH can be categorized as follows:

- Carbon/emissions trading
- Soft loans, senior loans and subordinated debts
- Conventional grants
- Subsidies for environment-related issues
- Government Viability Gap Funding (VGF) support
- Equity

(M.7) Detailed planning for electrification

Last but not least is the detailing of a technical plan for electrification in consultation with all relevant stakeholders. This step, which can be carried out once steps (M.1) to (M.6) have been finalized, is not discussed in this chapter.

14.3 Demographic, socioeconomic and geographic conditions in Mentawai Islands District

This section describes the unique situation that most remote communities in Indonesia face in terms of electricity access, resulting in the necessity to find radically different solutions for electrification—in other words, to find solutions other than the conventional electricity access widely available in major islands like Java and Sumatra.

14.3.1 Summary of geographical conditions

Mentawai Islands District is located in West Sumatra Province at a latitude of 0°55′00″ – 3°21′00″ S and longitude of 98°35′00″ – 100°32′00″ E. The district covers an area of approximately 6,011.35 km^2 and has 1,402.66 km of coastline. Geographically, Mentawai Islands District is separated from the West Sumatra mainland to the east by the Mentawai Strait. The district borders the Siberut Strait to the north, and the Indian Ocean to the south and west. In summary, Mentawai Islands District is an isolated region along Indonesia's western border.

The district comprises 99 islands, with Siberut being much larger than all others. Geographically and administratively, Mentawai Islands is made up of 10 subdistricts, 43 definitive village regions and 341 hamlets. The district has a varied topography, with coastal plains, rivers and hilly terrain. The average elevation of all the district's administrative capitals is two metres above sea level. The district capital, Tuapeijat, is located in North Sipora Subdistrict.

Based on Central Statistics Agency data (BPS 2018), Mentawai Islands District has 456,301 ha of forest cover making up 76% of the total district area. Only 3,096 ha or 0.5% of the district area comprises settlements. The average distance from Tuapeijat to Mentawai Islands's subdistrict capitals is 94 km, with boats or speedboats being the main means of transport for the local populace.

14.3.2 Population in Mentawai

The district's population in 2018 was 90,373, comprising 46,998 men and 43,375 women. Within the population, 12,990 people were categorized as poor due to having household incomes of less than USD 2 a day. The district has a Human Development Index (HDI) of 60.28, which is below the HDI of 71.73 for West Sumatra Province as a whole. Average population density in Mentawai Islands District in 2018 was 15 people per km^2. Sikakap Subdistrict had the highest population density at nearly 37 people per km^2, while West Siberut Subdistrict had the lowest at only 7 people per km^2. The total population aged 15 years and over in Mentawai Islands District was 57,790. Economic activities of the population are shown in Table 1.

Using data from Table 1, unemployment rates, calculated by the ratio of

$$\left(\frac{\textit{unemployed}}{\textit{economically active}}\right) \times 100\%$$

,

were 1.55% for men and 3.26% for women. Meanwhile, economic participation rates, calculated at,

$$\left(\frac{\textit{economically active}}{\textit{total population}}\right) \times 100\%$$

were 82.3% for men and 55.31% for women.

Education levels of economically active residents are shown in Table 2.

Table 2 shows that in 2018, almost half of the economically active population either had no educational background or only finished primary school.

Table 1. Population aged 15 and over by type of activity

Main activity	Men	Women	Total
Economically active	25,008	18,172	43,180
Working	24,621	17,579	42,200
Unemployed	387	593	980
Economically inactive	5,379	9,231	14,610
Attending school	3,075	3,085	6,160
Housekeeping	751	6,031	6,782
Other	1,553	115	1,668
Total	30,387	27,403	57,790

Source: BPS 2018

Table 2. Economically active population aged 15 or older by level of education

Education	Working	Unemployed	Total
No education or did not complete primary school	14,125	-	14,125
Primary school	12,741	119	12,860
Junior high school	5,773	79	5,852
Senior high school	6,793	782	7,575
Diploma I/II/III	813	-	813
University	1,955	-	1,955
Total	42,200	980	43,180

Source: BPS 2018

14.3.3 Electrification in Mentawai Islands District

At only 29.8%, the electrification ratio of Mentawai Islands District is significantly lower than the average for West Sumatra Province at 86.6% (Yoesgiantoro 2019). Most areas in the Mentawai islands use diesel-powered plants operated by PLN, which are not capable of operating for 24 hours a day. Data to December 2013 from the Mentawai Archipelago PLN division states that it had 5,524 customers across the archipelago's ten subdistricts. This was an increase from 2012, and PLN projected increasing numbers of customers in years to come.

In 2013, the subdistrict with the most PLN customers was North Sipora with 2,223, or 40.24% of all customers across the archipelago, most of them living in Tuapeijat. This was followed by South Siberut Subdistrict with 966 customers (17.49%), predominantly in Maileppet Village, and South Sipora Subdistrict with 862 customers (15.60%), mainly in the Sioban Village region.

Numbers of PLN customers above cover social, household, business and government users. The largest percentage of users, at 4,849 customers or 85.69%, was households, while the public sector accounted for the smallest percentage of users at 2.43%, or 134 customers.

14.3.4 Remarks on socioeconomic conditions in Mentawai Islands District

Due to the circumstances described above, Mentawai Islands District is considered a top priority region for electrification. As one of Indonesia's '3T' areas, its electrification ratio is still very low, and most of the district's power plants run on diesel and are incapable of providing electricity for 24 hours a day. Adding more power plants in the district would increase its electrification ratio. Overall, the potential exists to replace its diesel power plants with GHG emission reducing, renewable energy-based power plants.

The data from Table 1 shows the Mentawai people are economically active. They are also familiar with the local biomass (bamboo). Since rural areas in the Mentawai islands are an average 5-hour express boat ride away from the district's main towns, power plants needed to be developed in rural areas and had to be self-sufficient, meaning the fuel source must be obtained locally. This is also the reason why establishing diesel power plants across Mentawai Islands District would be prohibitively expensive. Consequently, a distributed power generation system using local sources of energy provided a better option. Implementing the business model in Figure 1 provided a dual incentive for Mentawai people with more employment opportunities and increased access to electricity. The business plan has contributed positively to the local economy and the wellbeing of the Mentawai people, while also promoting renewable energy projects.

14.4 Biomass gasification for power generation in Mentawai Islands District

The biomass gasification project in the Mentawai islands is being implemented by Clean Power Indonesia (CPI). Initial funding for the project came in the form of a Millennium Challenge Account (MCA) grant. Total funding for the project was USD 13.4 million (including detailed feasibility study), where 96% was covered by the MCA grant. CPI applied for and secured the MCA grant, and took on the role of independent power provider (IPP). Detailed technical planning (engineering, construction and procurement) was carried out by the contractor.

The main purpose of the project was to introduce and develop renewable energy power plants in rural areas inaccessible to PLN. Prior to project implementation, CPI approached the local PLN division to convince officials of the project's merits and the benefits for all stakeholders involved. This step (M.4), discussed in Section 2 above, was to emphasize that the power plant being developed by CPI would be owned by the Government of Indonesia, and eventually the local community, and that CPI's role would merely be as a developer and enabler. Further, the electricity produced from the biomass gasification would be sold to the public and managed by PLN.

Bamboo was chosen as the biomass source for the project. The choice of bamboo as the renewable energy source aligned with conditions (C.1) and (C.2) because it would have a minimal impact on existing ecosystems and result in reforestation. The following were the most important reasons behind the choice to use bamboo as the biomass source in the project:

- Bamboo is socially acceptable in the Mentawai islands, as local people have nurtured a deep familiarity with bamboo for generations.
- Bamboo has a small ecological footprint, as it is planted on marginal land.
- Bamboo is supported by a legal framework for community-based plantations from the Ministry of Environment and Forestry of Indonesia, which recognizes bamboo as being suitable for restoration (MoEF 2018).
- Bamboo is suitable as fuel in biomass power plants (Engler et al. 2012).

An illustration of project implementation in the Mentawai Islands is presented in Figure 2. The fuel for the power plants is synthesis gas from a bamboo gasification process. This process also produces ash, and charcoal that can be used as cooking fuel. In addition, gas exhausts from the bamboo biomass-based power plants can be used for crop drying. Consequently, using bamboo is the optimum and most sustainable choice for supporting the economic activities of the rural population, as many of its by-products have other uses.

Locations for the gasification project, which commenced in 2018, are the villages of Madobag, Matotonan and Saliguma on Siberut island. Madobag and Saliguma villages can only be reached by boat from the main town on Siberut in three and five hours, respectively.

Meanwhile, Matotonan Village can only be reached by walking for eight hours or by boat in around six hours. The total power generation capacity of plants in the three villages is 700 kW, which covers 1,181 households and 456 non-residential connections. Figure 3 shows the first time the lights were illuminated at the power plant in Saliguma Village, the first bamboo-based biomass power plant in the Asia Pacific region.

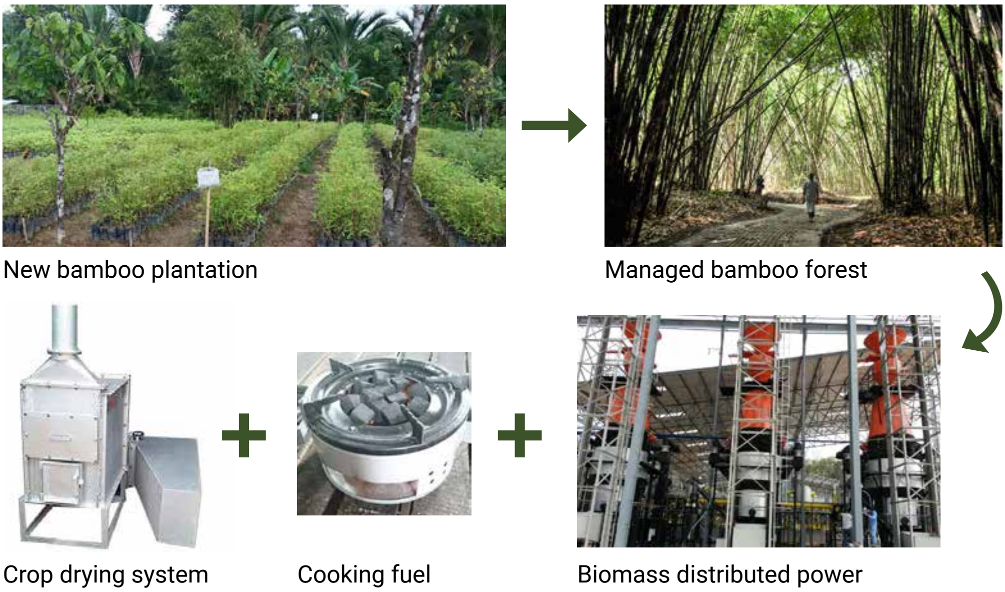

Figure 2. Illustration of project implementation in Mentawai Islands District

Figure 3. Documentation by CPI: The inaugural light up of the bamboo-fired power plant in Saliguma Village

Communities provide the bamboo as biomass for the power plants (Figure 1 in Section 2). Each household received 100 bamboo seedlings, where: (i) one seedling would provide 100 poles within five years, with (ii) one pole weighing 20 to 30 kg. Consequently, one household needs only two or three poles per month to meet its own energy needs. Community roles in supplying bamboo are illustrated in Figure 4 below. Figure 4 (a) shows villagers collecting and transporting bamboo poles from their plantation. Figure 4 (b) shows villagers drying cut bamboo poles, which must be dried for three days, and preparing them for collection by the IPP. Figure 4 (c) shows a representative from the IPP collecting dried cut bamboo poles for further processing at the power plant. In implementing these processes, villages apply consensus-based decision-making to establish how much bamboo each household needs to supply to avoid over-supply to the IPP.

Data from the Directorate General of New-Renewable Energy and Energy Conservation shows the monetary value of employment opportunities created by the gasification project in the Mentawai islands to be roughly IDR 2 billion per year. This figure includes contributions to communities for supplying bamboo to the IPP, and remuneration from jobs with the IPP, which are open to applicants from local communities. Meanwhile, according to the Alliance for Rural Electrification (ARE 2019), the biomass gasification project has created around 450 jobs. This employment creation is an important feature of the business model in Figure 1.

Features of the biomass gasification project in Mentawai Islands District are as follows:

1. Land concessions: The local government has given local communities the right to use land to plant bamboo, which ensures supplies of biomass for the power plants. In return, these land concessions have resulted in reforestation.
2. Accessibility: The electricity generated by the biomass power plants on Siberut island is managed by the local PLN. Thus, guaranteeing its accessibility to local communities.
3. Affordability: Local communities are remunerated for supplying the raw energy source to the IPP, and have additional income that can be used for purchasing electricity managed by the local PLN. Consequently, local communities are able to afford electricity.
4. Acceptability: Planting bamboo is socially acceptable for the people of the Mentawai islands. The local government also supports bamboo planting because it has always been done on marginal or unproductive land. From an outsider’s perspective, the planting of bamboo is widely acceptable as it reduces GHG emissions.
5. Sustainability: The business model is sustainable due to the guaranteed supply of biomass within a 5 km-radius of the power plants. Additionally, the IPP’s business is sustainable due to guaranteed electricity purchases from the local PLN. Finally, the local PLN can maintain a sustainable customer base and can benefit from the Environment Fund managed by BPDLH to reduce electricity prices.

Figure 4. Documentation by CPI: People in Mentawai: (a) collecting and transporting bamboo poles; (b) drying cut bamboo poles and preparing them for collection by IPP; and (c) IPP representative collecting dried cut bamboo poles

14.5 Conclusion

The gasification project in Mentawai Islands District discussed in this chapter conforms to four key conditions namely, (i) energy sources should be sourced locally (ii) the harvesting, process of the energy sources has a minimal impact on the ecological system and must involve reforestation efforts, (iii) the generation system must be dispatchable and (iv) the electricity produced must be equitable, reliable and affordable. and scalable. In addition, the project in Mentawai has shown that methodologies (M.1) to (M.6) described in this chapter can successfully realize the electrification of rural areas in Indonesia by using renewable energy.

Funding for the gasification project in Mentawai Islands District came from a Millennium Challenge Account (MCA) grant. Although this grant is not available to other regions, the project in Mentawai Islands District has shown that similar projects in other areas may receive financing from the Environment Fund managed by BPDLH, which could be used for supporting development. Community- and nature-based solutions for biomass planting will help to secure feedstock in the long term and create feedstock supply security for biomass power plants. This is a solution to promote biomass power plant development all over the country, while simultaneously replacing expensive and polluting diesel generators.

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