Biomass Energy Business Model on Sustainable Bamboo Forest

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BIOMASS ENERGY BUSINESS MODEL ON SUSTAINABLE BAMBOO FOREST

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Abstract

Background: This study objective to create a business model for the development of renewable energy based on bamboo forest biomass for underdeveloped and remote islands in Indonesia. Electrical energy has a vital and strategic role, to support national development and must be realized reliably, safely, equitably and environmentally friendly. Many problems occur in the management of the national electricity system, including dependence on the supply of fossil-fuel primary energy sources, as well as Indonesia's geographical condition which consists of many islands making it difficult to process the transmission and distribution of electrical energy. Electricity generation from renewable energy sources based on bamboo forest biomass can be a solution to the above problems. The research questions to (1) analyze what factors will influence uncertainty in the development of renewable energy based on bamboo forest biomass; (2) analyze the indicators of the success of the development of renewable energy based on sustainable bamboo forest biomass. (3) designing a business model for the development of renewable energy based on bamboo forest biomass in rural areas that can guarantee sustainable regional growth.

Methods: The study uses soft systems methodology techniques in the form of case studies supported by field surveys and literature studies. Qualitative analysis was carried out with a Focus Group Discussion and in-depth interviews with experts aimed at identifying indicators of success in developing sustainable renewable energy. The analysis technique uses two analytical methods, Strategic Assumption Surfacing and Testing (SAST) and Interpretative Structural Modeling (ISM). The location of the study was conducted in three villages in Siberut Island, Mentawai Islands Regency, West Sumatra

Conclusions: There were numbers of key elements in designing a business model for the development of renewable energy based on bamboo forest biomass, namely electricity subsidy rates, community forest land status, donor agencies, village community participation, income distribution and cooperative partnership of bamboo farmers. Business model that was designed in this study requires five things, specifically; (1) Clustering, (2) High tariffs, (3) Non-commercial funding, (4) Community Forestry, and (5) Community Empowerment.

Keywords: Bamboo biomass, Renewable energy, Business model, Sustainable Forest, Indonesia

Backgrounds

Introduction

Indonesia is an archipelago consisting of 5 large islands and $\pm$ 17,500 small islands scattered throughout the country and about 6000 inhabited islands. The main problem of development is the unequal availability of electrical energy and to date it still relies on fossil energy which requires quite expensive inter-island shipping [1]. Indonesia actually has a large number of potential renewable energy sources [2]. Almost all of these energy sources have been tried to be applied on a small scale in the country [3]. Cooperation, coordination between the Related Ministries and the support of industry, entrepreneurs and the community are very important to realize the implementation of these renewable energy sources [4]. Compared to other renewable energy sources, the available biomass source is greater, but the shift in the energy mix requires more investment in infrastructure, research and development [5]. In managing the country, especially in developing energy, renewable energy is the main factor that determines the success of sustainable development in a country [4]. The main benefits of sustainability such as the availability of energy will improve socio-economic life and poverty reduction in developing countries [6].

Sustainable development is a development process (land, city, business, community, etc.) that is principled to meet current needs without compromising the needs of future generations [7]. One factor that must be faced to achieve sustainable development is how to repair environmental destruction without sacrificing the needs of economic development and social justice [8]. Sustainable development with an environmental perspective is a conscious and planned effort that integrates the environment, including resources, into the development process to ensure the capability, welfare and quality of life of present and future generations [9].

Electricity generation from renewable energy sources should be able to increase significantly in the coming decades. However, uncertainty about the development of required infrastructure investment, community participation and the costs of developing renewable energy make the achievement of investment plans uncertain [10]. The risk of achieving renewable energy investment targets is a major obstacle in investment planning, because differences

in renewable energy design fundamentally change the optimal design of dispatchable power plants [11]. Specifically, uncertainties in the development of renewable energy affect uncertainty in the distribution of electricity distribution in Indonesia [12].

Reducing dependence on fossil fuels and reducing the environmental impact of the resulting CO₂ emissions is one of the most promising aspects of utilizing renewable energy sources [13]. The availability of various biomass sources makes renewable energy sources more attractive. Given the variability of biomass supply and sources, supply chain sustainability plays an important role in providing efficient biomass resources for producing energy [14].

A key question is how to ensure that the massive expansion of the use of biomass for energy matches other urgent environmental goals, such as reduced erosion and land degradation, reduced eutrophication, groundwater quality, land use for agriculture, nature conservation and protection of global biodiversity [15]. Importantly, the transition to a sustainable future is not only a matter of cost and technology; but also social developments such as sustainable lifestyles, market development and the balance between decentralization and centralized choices being addressed [16]. The transition to a sustainable world is a challenge for the future. It is now widely accepted that the concept of sustainable development includes three main aspects [17]; (1) Ecological balance (including the health of natural ecosystems, reduced use of raw materials, climate change, etc.); (2) Sustainable economic stability; (3) Social development and justice, which leads to situations where current generation activities do not jeopardize the opportunities of future generations.

Literature review

Ayenagbo et al. [18], in his study, stated that a sustainable energy supply is needed for country's economic development. Therefore to create a relationship between energy and sustainable socio-economic development, the economy must be driven by sustainable energy policies. Likewise O.Bonilla [19] concluded in his study that natural resources will be depleted soon. Therefore, the community as a whole needs to do better work to prevent depletion of natural resources, save energy, prevent pollution, and develop a more sustainable way of life. To achieve this sustainable goal, it is necessary to increase the amount of renewable energy production.

Lots of research related to the development of renewable energy. As is common in the business-to-business industry, the development process and the improvement process are the most important things in R&D activities. Likewise, the renewable energy research and development project aims to improve the existing conditions [20]. Cooperation, coordination between technical ministries and support from industry and the community are very important to realize the implementation of these renewable energy sources [21]. Research on the use of biomass as a source of bioenergy is carried out in many ways because biomass is considered sustainable, potentially environmentally friendly and because fossil resources will be depleted [22]. Research in Romania looks at the future of the projected use of renewable energy sources for economic development in which renewable energy from biomass will play a greater role and growth, without affecting people's food security [23]. Research conducted in the UK presents a comprehensive review of renewable energy sources that are sustainable due to low carbon and other mitigation measures to reduce the potential for climate change [24]. Zhou [25] in his study discussed the role of energy to develop agriculture in China and rural development, and introduced a new approach: Integrated Agriculture Bio-energy System (IAB) to overcome the challenges of sustainable agriculture and rural development. While the promotion of renewable energy (RE) is used and considered a key solution to address sustainable development issues. However, it is not clear whether RE development is really related to sustainable development in China or not [26]. The results of research conducted by Dong [27], found that the development of RE power plants has a greater correlation with GDP growth while being less associated with decreasing electricity consumption in fossil fuels and reducing CO₂ gas emissions. In many developing countries, the use of biomass as a means to produce energy is now relevant and gradually increasing renewable energy sources in their energy mix [28]. However, more research and development efforts on bioenergy in developed countries than in developing countries [29]. In developing countries, looking for alternative energy that involves available and renewable local sources is one of the main concerns [30]. Compared to other renewable energy sources, biomass is widely available in many developing countries [31]. However, a shift in the energy mix requires more investment in infrastructure, equipment and R&D in developing countries [32][33].

Renewable energy for rural development has received much attention in the research community [34][35][36][37][38][39]. While much research has provided valuable information on the status of renewable energy applications for developing countries in rural areas, there is still gap in comprehensive and methodological analysis framework on sustainability criteria [40][41]. Shen [42] in his research developed an effective method for realizing the concept of sustainable development in evaluating decentralization with renewable energy choices for rural development in developing countries. Vasudevan et al [43] designed and proved the concept of micro-industry using the tri-generation of biomass fuel power plants, for sustainable development in rural India. It can be concluded to manage renewable energy must be able to become an agent of development in rural area [44].

The Eco-innovation business model is a new concept promoted in the European Union as part of the Horizon 2020 strategy to build a sustainable economy, to promote innovation, smart growth and business initiatives [45]. Through eco-innovation the possibility of two types of goals which are ecological and economic can be achieved. This is the main benefit of an innovation that is oriented towards environmental issues [46]. In an effort to encourage the industry to take economic opportunities from developing and marketing eco-innovative products and services, it is necessary to examine aspects of non-technological innovation, particularly the role of business models in supporting successful commercialization, as well as the development of environmentally friendly technologies [47]. Green economy, green growth, and eco-industries concepts, all emphasize the sustainable use of resources, so that future generations do not experience scarcity of resources or at risk of a worse environment than previous generations [48]. The Eco-innovation business model identifies the role of social marketing, relationship marketing, marketing orientation, general green marketing strategies and marketing mix elements in improving financial and non-financial performance and green brand equity [49]. For companies the Eco-innovation business model, will produce a lower impact on the environment compared to traditional business models [50]. Green economic transformation become a guidance for eco-innovation and green business models act as a driver of eco-innovation [51].

The business model for healthy green growth emphasizes the need to ensure: 1) adequate and timely

profits and benefits (financial, political and social) to make valuable and sustainable investments; 2) inclusiveness, involving beneficiaries in the conception of green growth initiatives in order to ensure cultural, technical and social compatibility, and to ensure long-term sustainability; and 3) partnerships, not just public-private partnerships, but each level that provides the necessary financial leverage, risk sharing, technical expertise and stakeholders. "Supply" in terms of the green growth equation must include stimulation of new markets, innovation (often adapting knowledge gained from local wisdom), and the use of available local resources. These basic elements are needed to produce and maintain green growth [52]. Organizations can only be sustainable if the entire social system is sustainable. Structural and cultural changes are needed to facilitate corporate sustainability and the level of system sustainability [53]. The Sustainable Business Model and the eco-innovation process lead to a balance between value chains that respond to economy, ecological and social needs [54]. Despite facing some challenges in sustainability in bio-based businesses, such as land use conflicts, important benefits from sustainability, such as energy availability, lower emissions, improving socioeconomic life, and poverty alleviation are important goals in developing countries [55]. Based on a survey conducted by Sitnikov [56], currently environmental issues are receiving greater attention and exceeding the organization's competitive approach to applying them. Besides that the problem of social value chains increasingly requires careful attention [57]. In situations of economic and ecological turbulence, eco innovation theory can be used to design strategies that are more effective and proactive for business model strategies in order to meet the triple bottom line of economic, social, and ecological sustainability [58]. Green product innovation and green product process innovation will affect two green innovation value chain constructions: competitive advantage and the success of new green products [59]. Analysis of the impact of competitive advantage on green products is also needed as a partial mediator in the relationship between green process innovation and the success of new green products [60].

A sustainable business ecosystem is a competitive resource for companies and also a resource that can be managed to gain a competitive advantage [61]. Alignment, systemization, socialization, and coevolution as four strategic actions to build a sustainable business ecosystem [62]. Sustainable energy development takes a macro-economic

approach and / or policies that are specifically oriented towards rural electricity with recommendations for a finance model [63].

Business models that are market based and operate without subsidies are almost non-existent in theory - and also non-existent in practice [64]. It is difficult to design a viable business model due to changing market conditions, and the interests of competing stakeholders in the regulation of the business ecosystem, some business model ontologies can be used to conceptualize and evaluate business models [65]. However, the application of theory will not lead to a viable business model, because they ignore important design elements, such as design principles, configuration techniques, business rules, design choices, and assumptions and indicators of success [66]. Ecosystem valuation is a complex topic with extensive jargon and rapidly evolving techniques [67]. Although many related guidelines already exist, no one can provide a direct answer to business needs [68]. Before a business process can be configured into a concrete business process model, the points of variability of the business process need to be identified [69].

The concept of business model innovation as a change for the concept of business model ontology, affects at least one of the three dimensions of the business model, namely: value offer, value creation architecture and revenue model logic [70]. Osterwalder and Pigneur [71] defines business model as a representation of organizational value logic in terms of how it creates and captures customer value. This abstract and generic definition is made more specific and operational by the composition elements that need to address the customer, value proposition, organizational architecture (company and network level) and economic dimensions [72]. At present no results have been established on a broad empirical basis on how a successful business model must be configured [73]. According to Long et. al [74] in their study stated that certain elements play a key role in a business model that will influence its success.

Renewable energy development for sustainable regional development can be pursued through renewable energy based on community bamboo forest biomass. However, previous research shows that there is still a gap between the uncertainty of renewable energy development that can be overcome with the formation of supply chain institutions and value chains that can provide benefits to the actors and also the need for an eco-innovation business model that can ensure

its sustainability. This study aims to close the gap above.

Research questions

From the literature study indicate there are still gaps in the evidence and knowledge about the effects of local private sector activities in developing countries and how this is enhanced for sustainable rural development. This includes business cases in the company's sustainable operations strategy, as well as sectoral and national contributions to the sustainable growth of regional development from the local private sector [75].

Based on the above, it is necessary to have supply chain institutions and business models to run the biomass energy business in a sustainable manner. Business models and renewable energy supply chain systems are complex systems that consist of several things and together cause uncertainty including [76]; (1) Yield and purchase price of biomass raw materials; (2) Efficiency of conversion technology for raw material biomass to biofuel and / or bio electricity; (3) Biomass power plants capacity that impacts electric power output; (4) Selling prices and demand for biofuels and electricity; (5) Government incentives for renewable energy products.

Energy from biomass has great potential to be an alternative to fossil fuels [77]. One of them is biomass energy from bamboo can be processed in various ways (thermal or biochemical conversion) to produce different energy products (charcoal, syngas and biofuel), which can replace existing fossil fuel products. Bamboo biomass has superior fuel characteristics compared to most biomass and suitable for thermochemical and biochemical pathways to produce electrical energy [78]. Bamboo is a tropical and subtropical plant that is easy and fast growing throughout Indonesia, high regenerative capacity, resistant to environmental conditions, high biomass yields and short harvest periods [79]. Bamboo biomass deficiencies include, logistics and land requirements [80]. This can have a negative impact on the environment if it is not managed properly, therefore the selection of bamboo as a supply of energy raw materials needs to be carefully evaluated to avoid or minimize the risks that might occur and to make the best use of its potential in providing a sustainable supply of energy [81]. To run a company business, entrepreneurs need a business model to map of thinking about how the company will create, deliver, and capture economic, social and environmental values in order to be sustainable [82]. Creating a

sustainable business by paying attention to environmental issues and promoting smart growth in innovation in business initiatives, then to achieve these two goals, namely ecology and economics, an eco-innovation business model is needed [83]. The eco innovation business model is a business model that utilizes innovations that are oriented towards environmental issues. The concept emphasizes sustainable use of resources, so that future generations do not experience scarcity of resources or are exposed to environmental risks that are worse than previous generations [84]. From the literature search, more research on the business model for developing renewable energy, especially bamboo biomass, and its relation to regional development or rural areas that are left behind by community empowerment, is still needed.

Based on the formulation of the problem above, the questions to be investigated are as follows; (1) What factors will influence the uncertainty in the development of renewable energy based on sustainable bamboo forest biomass ?, (2) What are the indicators of successful development of renewable energy based on sustainable bamboo forest biomass ?, (3) What is the business model for the development of renewable energy based on sustainable bamboo forest biomass for rural areas? This approach enables this study to address the identified research gap. In the next section, we specify the methodical approach.

Methods

Location of survey research was conducted in the Mentawai Islands District, on Siberut Island, South Siberut Regency and Central Siberut Regency, Madobak, Matotonan, and Saliguma Villages in West Sumatra Province, Indonesia. Survey research activities is from April 2015 to March 2018. There are three reasons for choosing Mentawai as a research location; (1) This region is one of the lowest population densities in Indonesia and, apart from the mainland of Sumatra, makes it a good example for the economic development of underdeveloped regions; (2) Has extensive forests biomass and bamboo forests that are suitable for renewable energy materials. (3) This area really needs to be developed because it has fisheries resources, non-timber forest products and tourism which all require electrical energy for their development needs.

Design of this research is descriptive research, the research method uses soft systems methodology techniques in the form of case studies supported by

Figure 1. Research Framework

field surveys and literature studies. Qualitative analysis was carried out with a Focus Group Discussion (FGD) and in-depth interviews with experts aimed to identifying indicators of success in developing sustainable renewable energy. The analysis technique uses two analytical methods;

Strategic Assumption Surfacing and Testing (SAST) and Interpretative Structural Modeling (ISM).

The stages of the research carried out were literature review, field research, expert surveys and FGD. FGD was conducted based on field research data to produce a strategic indicator of sustainability based on 3

dimensions of sustainability; social, economic and environmental, followed by the SAST method and expert surveys using ISM method. Expert persons involved have the qualifications in academics, researchers, policy makers and practitioners, who have insight and knowledge in the field of renewable energy, especially based on forest biomass.

Furthermore, the ISM method is used to determine the hierarchical structure of elements and sub elements, identify key elements of each element and identify the characteristics of sub elements based on the level of dependencies and power drivers of the models studied. Modeling with the ISM method is a process that converts an obscure and complex system into a positive model. ISM is a modeling technique developed for strategic policy planning for institutional formulation. This ISM model will provide a very clear picture of a system of elements and their relationship flow. This study uses the ISM method analysis tool because the design of a business model for the development of renewable energy based on bamboo forest biomass is still a new and complex problem that requires opinions and theoretical views from experts in formulating the institutions needed in the structure of the business model designed.

Research framework

A sustainable business model means sustainability in economic, environmental, and social. In this study, analysis was carried out on these three dimensions. Therefore, we developed a research framework as shown in Figure 1. Problems in the social dimension, finding from field survey are institutional issues, so the proposed institutional design is needed in three villages in the Mentawai Islands Regency. The expected output is the establishment of institutional business stakeholders to provide facilities for the people in the three villages to get electricity and can improve their living standards.

On the environmental dimension, it is known from the results of the field survey that the most critical indicator is land conservation. Land conservation can have a negative impact if no further treatment is carried out, so in this study we analyzed the impacts that might occur. The expected output is the formation of a proposed strategy for land conservation so that it can increase the income of rural communities without damaging but actually increasing environmental sustainability. The problem in the economic dimension is to prevent the imbalance of profits obtained by the actors of bamboo biomass renewable energy supply chain. The expected output in this

model is obtaining information about the compensation mechanism for each actor that is able to balance profits on all fronts. Balance of profit distribution can motivate the community to participate so that the availability supply of biomass raw materials can be guaranteed.

Result and discussion

Identification of factors that influence uncertainty is needed as a basis for designing a business model for the development of renewable energy based on sustainable bamboo forest biomass, obtained from focus group discussions or FGDs, held in the Mentawai Islands District, West Sumatra Province, involving the Regional Government of the Mentawai Islands Regency, the Regional Planning Agency, Mentawai community leaders, Forest Service and Mentawai Islands Non-Governmental Organizations. These factors are the results of literature studies, previous research journals, and the results of field survey research which are presented in the FGD to get input. The results of the FGD produced conclusions about the factors that would influence uncertainty in the development of renewable energy based on bamboo forest biomass, as follows:

1. Supply of bamboo biomass feedstock.
2. Institutional supply chain.
3. Equitable distribution of income
4. Bamboo cultivation based on Biomass Power Plant specifications
5. Availability of forest land
6. Investment funds needed
7. Appropriate biomass technology to be developed

The availability of bamboo biomass raw material is an important issue that will determine the sustainability of this project. Therefore, one of the requirements for developing a Biomass Power Plant is that the availability of raw materials must be ensured throughout the operation of the project [85]. Obtaining bamboo biomass raw materials with sustainable bamboo forest cultivation is an important activity that must be realized [86], because it will guarantee the supply of bamboo raw materials in the development of renewable energy power plants in remote areas far from the State Electricity Company transmission network. To create sustainability of bamboo biomass raw materials it is necessary to analyze with indicators of sustainability success based on three dimensions; economically, socially and environmentally [87].

Identification of factors from FGD activities, then used as material for expert discussion activities

consisting of speakers who have the qualifications of academics, researchers, policy makers and practitioners, including from the Directorate General of Renewable Energy and Energy Conservation, the Indonesian Association of Industries and Development of Renewable Energy (ASIPEBTI), Indonesian Renewable Energy Society (METI), Experts from Indonesia's Millennium Challenge Account (MCA), Indonesian Center for International Forestry Research (CIFOR), Green Prosperity Mentawai Community (GPMC). This expert discussion was carried out in order to develop sustainability indicators that will be used in developing business models for the development of renewable energy based on sustainable bamboo forest biomass. From the results of expert discussions, we obtained 18 indicators of sustainability from the environmental, social and economic dimensions.

Using SAST method, the results of this expert discussion, as well as the results from primary data survey that measures and analyzes population perceptions, along with secondary data references, we carry out further synthesized to identify indicators of success for the most strategic sustainability. On environmental dimension, indicators of success for strategic sustainability that have the high level in importance and certainty include:

1. Adequate feedstock supply
2. Reduction of environmental damage
3. Land and forest inventory
4. Carbon neutral conditions

On social dimension, indicators of success for strategic sustainability that have the high level in importance and certainty include:

5. Community involvement in the supply chain
6. The dissemination of bamboo biomass energy is well distributed
7. Vocational education prepares local human resources.
8. Institutional supply chain
9. Absorption of labor

On the economic dimension, indicators of success for strategic sustainability that have a high level in importance and certainty include:

10. Investment funds
11. Increase in income of rural communities
12. Sources of electrical energy that are affordable to rural communities

While indicators of success for strategic sustainability that have a high importance but low level of certainty, for environmental dimension is:

13. Community Forest land status is required for

bamboo biomass-producing forests

14. Reforestation and community forest management arrangements

On the social dimension are:

15. Work culture aligned the needs of the project
16. Changes in community mindset in community forest management

On the economic dimension include:

17. Arrangement of partnerships between communities and power generation project
18. Electricity distribution must be from the State Electricity Company to consumers at subsidized rates

From SAST result analysis we get critical indicators of each dimension of sustainability that form the basis for designing business models.

Things that need to be ensured; 1) Status of community forest land must be realized and not change the designation, 2) Efforts to regulate reforestation and management of community forests need to be done consistently so that development of bamboo forests will overcome land damage and create carbon neutral conditions for power generation projects [88].

On social dimension, main critical indicators need support and involvement of the community in the supply chain, as well as the dissemination of renewable energy for bamboo biomass can be well distributed. The main characteristic of developing biomass power plants, other than biomass-based, must be community-based. Without community participation, this project will not be realized. It is very important for community involvement, especially in the supply chain of biomass feedstocks, therefore there is a need for institutional supply chains that can guarantee the supply of raw materials, reduce risks and regulate equitable distribution of income. This supply chain institution will also guarantee the availability of jobs [3]. Findings from the field survey exposed average community school education was only in grade 6 because only primary schools were available in that three target villages. Thus there is a need for vocational education to prepare workers in the project and bamboo farming coaching. The correct work culture and procedures for managing bamboo forests need to be taught to the community through vocational education and coaching activities.

On economic dimension the main indicators of sustainability are investment, increased community income and the availability of affordable electricity for the community. Results from field survey showed renewable energy development in remote areas

requires a large investment because the field conditions are far from adequate road infrastructure and the risk of failure is quite high because no similar projects have been implemented. The presence of grants institution is needed in pilot projects like this because even banking financial institutions also not willing to financing because the magnitude of the risk. Aim of the grant institution is to empower the economy of underdeveloped villages through the development of renewable energy. With this grants, developers are not burdened with the risk of investment failure, and then the cost of converting energy from biomass to electricity must be compensated by buying electricity from community with affordable tariff. On the other side biomass power plant beside require guarantee of feedstocks supply, also requires guarantee purchase and payment of electricity produced so that it can be sustainable.

PLN as Indonesian State Electricity Company in accordance with Law no.30 of 2009 [89], as an official distributor of electricity in Indonesia is public service obligation, should buy electricity according to the specified feed in tariff and distribute it to rural communities at subsidized rates, thereby providing a solution. However, PLN indicated that they did not yet have a plan to increase the level of electricity through the IPP scheme in the Mentawai Islands District, which meant that the transmission network would not yet be available in the three target villages, so developers had to prepare it. This causes the economic dimension, point number 18; the distribution of electricity by the National Electricity Company to

electricity consumers is high importance but the certainty is low in the SAST analysis.

From the results of SAST analysis described above, we get critical indicators of each dimension of sustainability that need to be considered in designing a business model for renewable energy development based on bamboo biomass. The next stage needs to be done is to analyze the structure of the model development using the Interpretive Structural Modeling (ISM) method for designing the intended business model.

Results Analysis of Model Development Structures

Structure of system element to determine business model of bamboo forest biomass-based renewable energy development is carried out using ISM techniques. Based on opinions of experts conducted through in-depth interviews and expert questionnaire surveys, there are six elements that need to be analyzed and translated into supporting elements. The six elements are:

1. Program goals
2. Program needs
3. Municipal Influencer
4. Program barrier
5. Possible changes
6. Institutional linkages

Program goals

The program goals have 8 sub elements identified and analyzed from expert discussions. The results are:

Figure 2. Program goals

Figure 3. Program needs

1. Increase in community income (G1)
2. Utilization of bamboo forests (G2)
3. Bamboo farming cooperative business (G3)
4. Increased regional income (G4)
5. Electricity availability (G5)
6. Environmental preservation (G6)
7. PLN subsidized rates (G7)
8. Expanding employment (G8)

The business model that we develop must be able to ensure the program's goals can be achieved so it can reduce poverty, pursue sustainable development in underdeveloped areas. Using the ISM method, the hierarchical structure of the program's goals elements and their relationship are as figure 2.

Based on the analysis using ISM method, PLN subsidized electricity tariff as the basis Independent Power Driver for other sub elements. This means that the distribution of electricity sales must be done with PLN in order to reach the electricity tariff in accordance with PLN's electricity subsidy rates. If the goal is achieved then other goals can be achieved such as; 1) the availability of electric power due to guaranteed payment from PLN for the electricity produced, 2) utilization of bamboo community forest products as feedstocks for generating power, 3) the bamboo farmer cooperatives business as an institution that manages the supply of bamboo biomass feedstocks for power plants and 4) the achievement of environmental preservation by maintaining bamboo forests. Furthermore, if these five goals mentioned above are achieved, it will contribute to the achievement of expanding employment goal, which in turn will contribute to regional income increase and the achievement of increasing local income and community empowerment. Based on the analysis

using ISM method, it is known that PLN's subsidy rates are key success of goal's element of this community-based renewable biomass bamboo forest power plant development program. Because electricity subsidy rates are not only related to Willingness to Pay from rural communities, but also the issue of equitable social justice for the whole community. If the capital city of South Siberut District in Muara Siberut, whose residents can enjoy PLN electricity subsidy tariffs because there is diesel power generation and PLN electricity network, while Madobag Village and Matotonan Village are located in the middle Siberut Island forest and the poor population will not feel equitable if they have to pay more expensive electricity tariffs than PLN's electricity subsidy rates.

Program Needs

The program requirement element analyzed has 8 sub elements identified from expert discussions result, with ISM method a hierarchical structure of sub elements of the program requirement can be arranged as figure 3.

Based on the hierarchy between the sub elements in the program needs element, the ISM results show, competent human resource, fair business profit distribution system, bamboo farmer cooperative business partnership, community participation and NGO aid/ Grant/ Carbon Credit Fund and business investment, all have high Drive Power and Dependence value and high linkages. This means that the five sub elements are very supportive of the other sub elements and are interconnected with each other with mutual influence. Therefore, the five sub elements must be considered and dealt with seriously.

Figure 4. Municipal influencer

The sub-elements of appropriate biomass renewable energy power generation technology, bamboo biomass raw materials through the management of idle land are in the dependent sector. This means that two sub elements are very dependent on the achievement of the five drive power mentioned above. Furthermore, if the seven sub elements are achieved, then electricity can be generated for the community.

The development of renewable energy based on bamboo biomass for development of undeveloped areas is an entirely new project especially in Indonesia. The project in Mentawai is expected to be a successful pilot project that can be replicated for development in other remote areas in Indonesia. There are no domestic and foreign funding institutions that have ever funded this project because the business model also not yet exist, to get funding is needed in the form of development grants so that projects like this can be running.

Municipal influencer

The influential society sector analyzed have 8 sub elements identified from expert discussions results, using the ISM method a hierarchical structure of sub elements of the influential society can be arranged as figure 4.

Based on the analysis using ISM method, the sub-elements Community leaders and Community Organizations / NGOs have a high value of drive power and independence. This means that the two sub elements are key elements that influence other influential society sector sub elements. These two sub elements influence other sub elements to interact with each other, such as the villagers around the power

plant, the bamboo farmer business cooperative, the village-owned enterprises, the power plant developer and the PLN to be able to produce and distribute electricity to the last sub-element, the electricity consumer.

Biomass-based renewable energy characterizes the need for community participation to be involved in its operations. Without the role of the community the project will not work, because; 1) there will be no guarantee of biomass feedstocks supply, and energy plants not having ability to land acquisitions for bamboo cultivation, the concept of community forestry requires community participation as a biomass producer. 2) no community empowerment occurs which results in the community not having the ability to pay electricity bills even if they are subsidized. 3) there is no income distribution which results in not achieving the main objective of the development of this project for the development of undeveloped rural communities. ISM analysis results on influential society sector show the role of Community leaders and NGOs such as the Mentawai Green Prosperity, to mobilize the community will be very necessary in addition to other stakeholders related to energy development including private developers, district-owned enterprises, PLN, Cooperatives Bamboo Farmers Business and target village communities.

Program barriers

Analysis of the main obstacles in the development of renewable biomass energy is very important to be considered and handled carefully and systematically

Figure 5. Program barrier

so that the project can run with guaranteed supply of biomass and sustainable. By using ISM method a hierarchical structure of sub elements can be arranged from main obstacles of the program as figure 5.

The main obstacles factor for bamboo forest biomass-based renewable energy program is the availability of sufficient bamboo biomass feedstocks and must be able to be managed in order to be sustainable. For the purposes of bamboo forest management, it requires a community forest policy that regulates the status of forest land. Based on the analysis of the ISM method, there are two sub elements that form the basis for other sub elements, which are; forest land status and community forest policy. If both of these obstacles can be resolved, then it can overcome the limitations of superior species of bamboo that are needed as biomass raw material by cultivating and planting the superior species of bamboo on forestry land that has the status of community forest. Furthermore, after adequate wet biomass are available and a dry biomass price standard has been set, dry bamboo biomass feedstock will be available that are ready for energy conversion. With the availability of sufficient feedstocks and certain price standards, it will facilitate the calculation of the investment value of bamboo biomass renewable energy development business, the determination of appropriate power generation energy conversion technology, infrastructure development and vocational education facilities needed to prepare competent human resources.

Possible changes

The possible change element analyzed have 8 sub elements identified from the results of expert discussions, using the ISM method a hierarchical structure of sub elements of the possible elements of change can be arranged as figure 6.

Fundamental changes are needed so that the biomass energy development program can run sustainably. Changes to the Spatial Plans and Regional Regulations are needed for community forest management. Also changes in productive work culture, and creates value chain in forest management. Based on the hierarchy between elements of the analysis using the ISM method, the regional spatial plan sub-element becomes the main basis for other sub-elements because it has the highest and independent drive power. If the spatial plans is prepared properly and carefully, it will produce an effective community forest management regulation. Furthermore, if both of these things can be produced and approved, it will have an impact on the smooth development of a bamboo farmer cooperative with a productive work culture, create value chain in the management of community forestry, optimizing land use in REDD+ efforts, forming an electric region-owned enterprises. These five sub-elements which are interrelated will be able to guarantee the achievement of rural electricity availability.

Figure 6. Possible changes

Institutional linkages

Efforts to design a business model need an analysis of which institutions are related, influential and involved in supporting the implementation of this project and how the hierarchical relationship patterns. Because the influence of stakeholders will largely determine the realization of this project. By using ISM method a

hierarchical structure of sub-elements of related institutional can be arranged as figure 7.

Development of renewable energy based on bamboo forest biomass as a solution to the development of disadvantaged areas is certainly inseparable from the role of the Indonesian National Development Planning Agency (Bappenas) as the coordinator and manager of grant funds. Based on the results of the research

Figure 7. Institutional linkages

analysis, the hierarchy between the sub elements with the ISM method on related institutions element, there are 3 sub elements that have the highest thrust and become the basis for other sub elements, namely grant institutions, Indonesian Chamber of Commerce & Industry, research centers and College. The role of the three sub elements will support Bappenas in planning. Furthermore, the four sub-elements will support Indonesian Ministry of Environment and Forest (KLH), Indonesian Ministry of Energy and Mineral Resources (ESDM) and Indonesian State Electricity Company (PLN), which work interrelatedly in regulating the policies that will be implemented by the Mentawai Islands District Government which will then be implemented by private companies as developers of renewable bamboo biomass-based power plant.

From the structuring of system elements using the ISM method described above, it can be indicated what factors influence the establishment of a business

model for the development of renewable energy based on sustainable bamboo forest biomass. A number of sub elements are indicated that play a key role in each element. Furthermore, the results of these analysis and discussion using the ISM method above can be summarized as table 1.

The key sub elements of the ISM method analysis must absolutely be sought and related sub elements need to be considered because they have the driving force to achieve the target elements. It can be concluded from the ISM analysis above, the main objectives of the program according to the results on the target elements, which is; “The availability of electricity for rural communities, produced from renewable biomass energy that is environmentally friendly, to improve the welfare of the community through rural economic empowerment”. This main objective becomes the value proposition of the business model to be designed. These all sub elements form the basic design of supply chain institutions

Table 1. Key Elements of Designing a Biomass Energy Business Model Based on Sustainable Bamboo Forest

No.	Program Elements	Contextual Relationship	Key Elements	Related Elements	Targets Element
1	Program Goals	Contributing to the achievement of goals	PLN Electricity Subsidy Rate	Employment Opportunity Environmental Conservation Availability of Electricity Sustainable Bamboo Forest Bamboo Farmer Business Cooperative	Increased Community Income Locally-generated Revenue
2	Program Needs	Support program implementation	Competent Human Resources Fair Profit Distribution Cooperative Business Partnership Community Participation Investment Funds	Appropriate Technology Management of Fallow and Unused Forest Land	Electric Energy for the Community
3	Municipal Influencer	Influence program implementation	Community Leaders NGO Green Prosperity Mentawai	Villagers Bamboo Farmers' Cooperative Village-owned Business Entity Private Developer PLN	Rural Electric Consumers
4	Program Barrier	Causing further obstacles	Forestry Land Status Forestry Policy	Availability of Biomass Raw Materials Standard Price for Biomass Raw Materials	Certainty in investment Appropriate Biomass Technology Improvement of village infrastructure Vocational Education
5	Possible Change	Resulting in further improvements	Regional Spatial Planning Regional Regulation on Community Forest Management	Farmers Business Cooperatives Improve Work Culture Forest Management Value Chain Optimization of Forest Land Based on REDD+ Village-owned Electricity Mgmnt Body	Availability of Rural Electricity
6	Intsitutinal Linkage	Play a role in supporting the program	Grant Institutions Center for Research & Higher Education Institute Indonesian Chamber of Commerce and Industry	PLN ESDM KLH National & Regency Development Planning Agency Regency Government	Collaboration between village-owned enterprises and private developers in the bamboo biomass power project

needed and become a reference in designing business models for biomass energy on sustainable bamboo forest.

Sustainable supply chain strategies and Institutional Analysis

To design a biomass feedstock supply chain system with sustainable bamboo community forest empowerment, it is necessary to analyze the needed supply chain institutions. Supply chain institution is the relationship of raw material management (feedstock management), or a systematic and mutually supportive work system among several supply chain partnership institutions in order to achieve one or more goals that mutually benefit all parties in the supply chain institution itself and benefits for parties outside the institution [90]. Supply chain institutions include actors from the entire supply chain, applicable mechanisms, patterns of interaction between actors, and their impact on business development and on improving the welfare of actors in the supply chain [91].

With the results from library and previous research, FGD, expert discussions and from analysis result using ISM method, the exchange mechanism by the supply chain actors for bamboo raw materials and electrical energy distribution is designed as follows; 1) Bamboo farmer supplier groups manage their respective land specified in community bamboo forests, prepare land, plant bamboo shoots obtained from nurseries through cooperatives, treat and harvest bamboo stems according to the specified size, then a number of bamboo stems are brought to the cooperative to receive compensation for their efforts. 2) Farmer Business Cooperatives collect bamboo from farmers, cut it into pieces the specified size (chips), then dry in the sun a few days before wrapped in sacks and then taken to the biomass power plants to get compensation for the results of their efforts. 3) Bamboo nurseries and greenhouses prepare superior bamboo shoots that have been planted from tissue culture into ready-to-grow shoots and control the quality of bamboo biomass that is suitable for harvest by farmers in managed bamboo forests. 4) Power

Figure 8. Structure and Mechanism of Sustainable Supply Chains and Value Chains

plants receive bamboo chips from the cooperative to be stored in a supply area, then dried on a special broiler machine so that the maximum water content is reached, then put it into an energy conversion machine with a gasification process to produce syngas which will then drive the generator engine producing electricity. The electricity produced will be transmitted to rural electricity consumers through PLN, which will then pay according to the feed in tariff written in the Power Purchasing Agreements (PPA) between PLN and power plants company. 5). PLN then distribute electricity to rural electricity customers through the rural off-grid network. 6) Rural electricity consumers using a voucher-based meter receive electricity and pay (buy vouchers) according to their use.

With the exchange mechanism as mentioned above, availability of feedstocks amount and quality required by the power plants will be guaranteed and there is a guarantee of payment from PLN and customers due to the existence of PPA and the use of voucher-based electricity meters. So that it will have a sustainable impact on business development and the welfare of supply chain actors. See figure 8.

The supply chain mechanism will also ensure the achievement of a sustainable value chain. The value chain expected by the supply chain actors is as follows

Electricity Consumers want:

- Electrical energy is available 24 hours as needed
- Having the ability to buy electricity vouchers
- Electricity subsidy rates for housing consumers

PLN wants:

- Energy supply according to customer consumption
- Feed in Tariff is lower than producing energy itself

The biomass power plant wants:

- Guaranteed supply of biomass chips
- Bamboo farming cooperatives wants:

- Supply of viable bamboo shoots
- Payment of biomass chips on time

Group of farmers wants:

- Payment for collecting bamboo stems on time
- Superior bamboo shoot ready for planting
- Counseling from the nursery

Bamboo nurseries & greenhouses wants:

- Payment of work according to the contract

With the structure and mechanism above, where the value chain and supply chain can be controlled properly, it is expected that the value proposition can

Figure 9. Output Input Diagram of the Sustainable Bamboo Biomass Renewable Energy Business Model

be achieved through designing a business model for renewable energy development based on bamboo forest biomass. The value proposition to be realized according to the target elements in the ISM analysis results are:

1. Renewable Green Energy
2. Sustainable Welfare
3. Empowerment of the Rural Economy

Requirements needed to realize this value proposition is the existence of management control as illustrated in the following Input Output images as figure 9.

With the Input Output diagram and based on the analysis of the model development structure with the ISM method discussed earlier, it can be designed a business model for the development of renewable energy based on sustainable bamboo forest biomass. By considering the results of previous research and analysis, it can be designed a business model for renewable energy development based on sustainable bamboo biomass as shown in figure 10.

Figure 10. Structure of the PPP-BOOM Business Model on Sustainable Community-Based Bamboo Forest Biomass Energy

Discussions

Managerial implications

The business model of community-based renewable energy development of bamboo forest biomass addresses technical complexity, economies of scale, capital costs, and challenges of renewable energy funding. For small to medium scale projects and not connected to the main network (off-grid), the most appropriate is the form of business model of Public-Private Partnership (PPP), which is implemented in the form of Build-Own-Operate- Maintenance (BOOM). This PPP scheme will require the existence of a company with a specific purpose or called a Special Purpose Vehicle (SPV) to develop, build, operate and maintain these assets (projects). The SPV will enter into a Power Purchasing Agreement (PPA) contract with PLN and with an Engineering, Procurement, and Construction (EPC) contractor to build the power plant facility and also enter into a contract with the Operational & Maintenance (O&M) service provider. Benefit of PPP scheme is that allows allocation of specific risks to the parties who are best able to manage them, while the shortcomings can be very complex, involve high transaction costs, and expensive for the public if the risk of misallocation arise, due to the complexity and high overhead costs, more suitable BOOM implementation.

SPV ownership must be composed between Village Regency-Owned Enterprises by 51% and private sector developers by 49%, because; 1) Communities

that must share through Regionally Owned Enterprises for the benefit of the development and welfare of rural communities. 2) Private developers with their capabilities must be able to manage with good business principles so this business can run sustainably.

The main issue in the business model of this research is the size of biomass power plants capacity must be precise with the projected demand for electricity supply, guaranteed availability of biomass and the ability to pay of customers, these are key factors in this project sustainability.

Indonesia as a large and small archipelagic state that are spread across all regions, requires an unconventional approach to electrify rural communities which live on small islands. Because conventional systems cannot reach equitable, reliable, affordable and sustainable electricity supply for remote islands.

The business model with the Mutual Cooperation Electricity Scheme (MCES) combines 3 actors: community groups, private business entities and the State Electricity Company (PLN) as an arm of the government into a unified system for realizing electricity supply in undeveloped areas. Communities planting bamboo in community forest areas, private businesses invest in biomass power plants and PLN provides electricity at affordable subsidized tariffs evenly to disadvantaged communities. Seen in Figure 11 the business scheme is intended.

Figure 11. Mutual Cooperative Electric Scheme

With MCES like this, community empowerment and sustainable business schemes will be achieved.

Eco-innovation Business Model Canvas

The target of renewable energy development based on bamboo forest biomass is for the development of undeveloped areas by empowering the community, which means covering a wider social area outside the control of the organization so that institutional development is needed. The mechanism is created new designs and introducing environmentally friendly products and completely new processes so that they will have an impact that refers to the effects of eco-innovation on environment and creation of Green Industrial Ecology [51].

To understand the mechanism of eco-innovation in the green business model, it will be more easily understood by building blocks from the canvas business model of Osterwalder and Pigneur [71], in this way the proposed eco-innovation target can be translated into a block business model. The canvas business model is a business model that consists of 9 blocks of business activity areas, which have the goal of mapping out strategies to build a strong, sustainable and successful business in the long run [54].

Value Proposition

The value proposition offered in this study is to create a Green Industry Ecology. In accordance with the results of previous ISM analysis where target elements are the value to be achieved in this business model, the objectives of Value Proposition to be realized are; (1) Renewable energy based on community bamboo forest biomass or called Renewable Green Energy. (2) The welfare of the target village community increases with the availability of electricity that is affordable to the community. (3) Preservation of a green environment

with the management of community forestry aimed at empowering rural communities.

The value proposition for developing business model in this research is very important to be realized so this business can be sustainable. Renewable energy based on community bamboo forest biomass also means it must be community based, without community participation as a bamboo farmer, this business will not be sustainable. The community will involved in this business if their welfare also increases, so community empowerment is very important in this business which is directly related to rural economic empowerment. Without efforts to improve the welfare of the community through their involvement as suppliers of biomass raw materials, the renewable energy generation business will not be sustainable. The potential of the rural economy through home-based handicraft industries as well as agriculture and fisheries requires the existence of electrical energy for the production process. With electricity coming into the village, rural economic empowerment will begin immediately.

Customer Segment

The customers faced are segmented customers, this market segments have different activities but in one category require electrical energy and play an active role in the production process in the MCES.

The development of renewable energy in this research is not only based on bamboo forest biomass but also community-based, so that rural communities in addition to being consumers of electricity, also play an active role in ensuring the supply of biomass raw materials according to the needs of power plants.

The distribution of electricity to the customers above is carried out by PLN with an electricity voucher payment system. The power plant company will receive payment for electricity production from PLN

Table 2. Customer Segmentation and Electric Power Usage

	Madobag	Matotonan	Saliguma	Total	Total Power	Power User Segmentation
Household	576	281	394	1,251	437,850 VA	76.92%
Public Facility						
Industrial Facility power capacity 5000 VA	2	1	3	6	30,000 VA	5.27%
Business Facility power capacity 5000 VA	2	1	5	8	40,000 VA	7.03%
House of Worship & Public Health power capacity 1350 VA	3	3	3	9	12,150 VA	2.13%
Education Facility power capacity 1350 VA	2	2	2	6	8,100 VA	1.42%
Regency Office & Municipal power capacity 1350 VA	2	2	2	6	8,100 VA	1.42%
Lighting Facilities & Public Street lights LED 100 watt	110	110	110	330	33,000 VA	5.80%
Total of Household & Public Facilities Electric Power	697	400	519	1,616	569,200 VA	100.00%

Key Partner (Stakeholders)	Key Activities (value creation activities)	Value Proposition	Customer Relation	Customer Segment
Investor (Grantors) Mentawai Regency NDPA RDPA R-owned Enterprises PLN Farmers Cooperatives Village Community Nursery Greenhouse O&M service co. KLHK Carbon Market	Energy Conversion Partner Management Customer Relation Management Carbon Certification	Renewable Green Energy (bamboo biomass electricity) Sustainable Welfare (lighting facilities & clean water) Rural Economic Empowerment (community forest management) Gold Standard Certified Carbon Emission Reduction (environmentally, socially & economically sustainable)	Longterm Community Co-creation (through socialization, counseling and bilateral) Channels PLN Village Community Farmers Cooperatives Carbon Market	Village Community Regency Office School House of Worship Public Health Center Public Facility Industrial Area Municipal Carbon Credit Buyer
Cost Structure		Revenue Stream		
Investment Cost (Capital Expense/ Capex) Operation Cost (Operational Expense/ Opex) + carbon certification costs		Grants/ Softloans Investment = Capex Payment from PLN (Feed in Tariff) Profit = Feed in Tariff - Opex +sale of carbon credits		

Figure 12. Biomass Energy Business Model Canvas Based on Sustainable Community Bamboo Forest

with a feed in tariff scheme. Table 2 is customer segmentation data and the percentage of power usage results from field survey research.

As can be seen in table 2, more than 75% of segmentation of power users are rural household whose condition of the community structure is more than 60% poor households. Therefore, empowering rural communities is important in this business model. Besides the electricity customers above, this renewable energy company can also market carbon credits in the carbon market.

Customer Relationship

There are three things that must be carried out in this business model in establishing relationships with customers, which are; 1) This relationship will be long term and must not be interrupted to be sustainable (long-term relation). 2) This relationship is carried out with the customer community of rural communities who at the same time also as a group of suppliers of bamboo biomass raw materials (community relations) and 3) This relationship must be able to create value that can be felt together with the benefits for both parties, the community can benefit from electricity and additional income and on the other hand the power plants company gets a guaranteed supply of feedstocks (co-creation).

Channels

In order to create a sustainable electricity business, the distribution channel is carried out by the State Electricity Company (PLN), where PLN will act as an off-taker of the amount of electricity generated by the power plant using a feed in tariff scheme and deliver electricity to the public at subsidized prices. On the other hand SPV, bamboo farmer cooperatives and the customer community play an active role in creating mutual awareness and electricity awareness to evaluate the value proposition offered. SPV sells carbon credits through national and international carbon markets.

Key Activities (value creation activities)

It is the main activity carried out by SPV to produce the value proposition offered and revenue stream. The main activities are; (1) Carry out the stages of energy conversion from bamboo biomass to electrical energy. (2) In conducting this activity there needs to be management of relationships with Key Partners (Partner Management), (3) Management of customer relationships (Customer Relationship Management) and (4) Submission of carbon certification in order to market carbon credits on the carbon market.

Key Partners (Stakeholders)

Success in running a business cannot be done by the company itself, there needs to be other parties who

participate so that the business can run sustainably. In accordance with the ISM analysis results on the relevant institutional program elements, there are a number of stakeholders that have a role in supporting this business activity.

Key Resources

Key resources are the most important things that SPV has to control so that key activities can be carried out and value propositions can be proposed. According to Input Output analysis result, management of controls which are key resources, are;

1. Green bamboo community forestry productivity,
2. Quality of bamboo biomass,
3. Institutional supply of bamboo biomass

Cost Structure

A cost structure is a breakdown of the largest costs that must be incurred to carry out key activities and produce a value proposition. These costs are investment or capital costs (capital expense/ capex) and annual operating costs (operation expense / opex).

Revenue Stream

Revenue stream attempts to generate profits from value propositions. To be able to cover investment costs / capex needs to be sought through grants (soft grants) or soft loans and carbon credit financing (Carbon Credit Funding). The investment needed is in the form of grants and soft loans besides that it is necessary to utilize the carbon market to obtain climate change carbon credit funds through the Clean Development Mechanism (CDM) and Joint Credit Mechanism (JCM). While operating costs can be overcome through selling electricity to PLN through

the feed in tariff scheme. Thus business profits will be obtained from feed in tariffs - opex = profit.

Figure 12. is building block Business Model Canvas Eco-Innovation for Renewable Energy Development Based on Sustainable Bamboo Forest Biomass

Model Conceptual Validation

The business model above has been presented to four experts. They are; expert 1 from the Indonesian Directorate General of New Renewable Energy and Energy Conservation Head of the Directorate of Bioenergy, expert 2 from the Association of Industry and Performers of Renewable Energy Development in Indonesia (ASIPBETI) President Director of Clean Power Indonesia (CPI), expert 3 from the Indonesian Renewable Energy Society (METI) Chairman, as well as expert 4 from the Millennium Challenge Account (MCA) of Indonesia, Deputy Director for Community-Based Renewable Energy. They were asked to evaluate the business model based on the above criteria and were asked to score the following on a scale of ++ (very positive), + (positive), +/- (neutral), - (negative), - - (very negative).

From Table 3. the experts give an evaluation of the business model is feasible to apply. Table 4. illustrates the evaluation of experts applying the design elements to design business models. Expert 3 has doubts about the assumption that SPV will be able to market energy at the same profit margins as traditional energy suppliers, given that biomass energy is very dependent on the acquisition price of raw materials. Expert 3 has doubts because of the large uncertainties in terms of obtaining raw materials and on the other hand SPV has no economies of scale yet. The experts responded positively about the completeness, validity, and coherence of the business model. Based on the above

Table 3. Expert Evaluations of Business Models

Evaluation Criteria	Expert 1	Expert 2	Expert 3	Expert 4
Viability in terms of value	+	+	++	+
Technological viability	++	+	++	++

Table 4. Expert Evaluations of Applied Design Elements

Evaluation Criteria	Expert 1	Expert 2	Expert 3	Expert 4
Validity of assumptions	+	+	+/-	++
Completeness of assumptions	++	++	++	+
Coherence of assumptions	++	+	+	++
Validity of business rules	+	++	++	+
Completeness of business rules	++	++	+	+
Coherence of business rules	+	++	++	++

evaluation it can be said that this business model is feasible to be applied.

Limitation of the study

This business model aims to create renewable green energy that is beneficial to improve the welfare of local communities and overcome forest degradation and restore fallow land to green again. Therefore, this study only limits renewable energy from biomass, especially bamboo plants that are produced from community forests that are sustainably managed to have the desired impact.

This limited business model can only function if there is local community participation through business activities in the form of cooperatives so that business interests are only for the welfare of farmers.

As discussed in the discussion section, each business model is very typical with the conditions encountered in the place under study, so replicating this business model elsewhere even still in rural area Indonesia will require survey research first. However, the business model developed in this study can be used as a reference for further research needs. This research is an action research study and is still ongoing to evaluate the changes needed to get appropriate results to empower the surrounding community in Mentawai.

Conclusions

Business model for the development of renewable energy based on sustainable bamboo forest biomass will provide policy makers and investors a business reference for the adoption of environmentally friendly technologies, or for the adoption of appropriate technologies and practices in a new environment. This model is designed to overcome various obstacles in investing, including covering the following subjects: 1) Lack of information, which causes a lack of awareness and knowledge of the importance of renewable energy; 2) Regulatory obstacles, which make procurement regulations and licensing processes impractical; and 3) Financial constraints, reflecting underdeveloped banking services on environmental problems, high initial investment costs, and low investment returns.

The business model developed in this research focuses on how to spread risk and overcome financial hurdles to invest in renewable energy projects, and to facilitate that investment can run smoothly. The structure of the business model is how business investment is designed, implemented and managed, by combining the important features of financing, service

and monitoring. The business model that is most suitable for a particular project will depend on local conditions, the financial and regulatory environment, as well as existing institutional and support mechanisms. The business model is not a standard structure; each model must be adapted to local conditions and the risk profile of the project being carried out.

In general, a project is valued primarily in terms of financial feasibility. But for biomass renewable energy projects also have important public benefits, which cannot be identified or cannot be offset financially. Biomass-based and community-based rural electrification projects can contribute to the following benefits: 1) Labor savings (from not having to collect bamboo); 2) Reducing deforestation (from dependence on fuel wood); 3) Health benefits (from reduced indoor air pollution and improved clean water and sanitation services); 4) Educational benefits (from improving lighting in schools and residences, and better learning conditions); and 5) Reducing poverty (from improving agricultural productivity and home industries). Such benefits will be difficult to reflect in the large electricity tariffs for consumers. Therefore, the right business model requires public subsidies or it is endeavored that the tariff charged to consumers will only cover the cost of electricity production.

The results of the business model research conducted on the island of Siberut, Mentawai Regency, West Sumatra Province have shown that this business model can be accepted by the community around the plant, the Regional Government, PLN and National Development Planning Agency as a form of cooperation that can be replicated to other villages in Indonesia that have the same characteristics as the villages of Saliguma, Madobag and Matotonan. The community gets as much as 100 bamboo shoots for each head of the family which will be their "energy savings and income" in the future.

The replication of business model for development of renewable energy based on bamboo biomass community forests is not possible in a business as usual or commercial business manner because the uncertainty remains high so the business risk is also very high. The steps taken in overcoming uncertainty in this business model, however, still require the role of many parties, not only the private sector but also including the relevant government agencies and primarily the involvement of the target village community. However, the benefits of sustainability if properly managed socially, economically and environmentally will be very high and contribute to

improving the welfare of remote rural communities, overcoming problems of land degradation and deforestation and contributing to reducing carbon gas emissions.

Replication of this business model for other remote island regions in Indonesia requires substantial funding, but to be successful according to the results of this study, the following 5 requirements are needed: 1) Clustering, Distributed rural electricity development is necessary covers a fairly large area (one island or one district) so will provide an economic scale for capex and low opex. 2) High tariffs, in the Indonesian archipelago having an official electricity supply price above 18 cents US\$ / kWh can provide feed-in tariffs above 15 cents US\$ / kWh (according to Permen 50/2017). Thus this energy plants can provide adequate business results for the private sector. 3) Non-commercial funding, grants and soft loans must be endeavored so that the risk of generating investment can be minimized. The expected grant is a compensation (carbon credit / offset) from developed countries to developing countries to switch from fossil energy to renewable energy.

Abbreviations

ASIPEBTI: Asosiasi Industri dan pelaku Pengembangan Energi Baru Terbarukan Indonesia/ Association of Industry and Performers of Renewable Energy Development in Indonesia; Bappenas: Badan Perencanaan Pembangunan Nasional/ National Development Planning Agency; BOOM: Build Own Operation & Maintenance; CDM: Clean Development Mechanism; CIFOR: Centre for International Forestry Research; CPI: Clean Power Indonesia; EPC: Engineering Procurement Construction; ESDM: Energi Sumber Daya Mineral/ Indonesian Ministry of Energy and Mineral Resources; FGD: Focus Group Discussion; GPMC: Green Prosperity Mentawai Community; ISM: Interpretive Structural Modelling; JCM: Joint Crediting Mechanism; KADIN: Kamar Dagang dan Industri Indonesia/ Indonesian Chamber of Commerce and Industry; KLHK: Kementerian Lingkungan Hidup dan Kehutanan/ Ministry of Environment and Forestry; Kwh: Kilo watt hour; LSM: Lembaga Swadaya Masyarakat/ Non-Governmental Organization (NGO); MCA: Millenium Challenge Account; MCES: Mutual Cooperation Electricity Scheme/ Skema listik gotongroyong; METI: Masyarakat Energi Terbarukan Indonesia/ the Indonesian Renewable Energy Society; O&M: Operation & Maintenance service company; PLN: Perusahaan Listrik Negara/ State-owned Electricity Company; PPA: Power Purchasing Agreement; PPP: Public Private Partnership; RE: Renewable Energy; SAST: Strategic Assumption Surfacing and Testing; VA: Volt Ampere.

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Authors' contributions

JWKW contributed to do research, design of the work, acquisition of data, analysis and interpretation of data, drafting of the work, and management work. Prof. US contributed give guidance in the field of Human Ecology and key notes in expert discussions. Prof. BA contributed give guidance in the field of Agribusiness Strategic and key notes in expert discussions. Prof. HP contributed give guidance in the field of Forest Management and key notes in expert discussions.

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Competing interests

The authors declare that they have no competing interests.

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Figures

Figure 1

Research Framework

Figure 2

Program goals

Figure 3

Program needs

Figure 4

Municipal influencer

Figure 5

Program barrier

Figure 6

Possible changes

Figure 7

Institutional linkages

Figure 8

Structure and Mechanism of Sustainable Supply Chains and Value Chains

Figure 9

Output Input Diagram of the Sustainable Bamboo Biomass Renewable Energy Business Model

Figure 10

Structure of the PPP-BOOM Business Model on Sustainable Community-Based Bamboo Forest Biomass Energy

Figure 11

Mutual Cooperative Electric Scheme

Key Partner (Stakeholders)	Key Activities (value creation activities)	Value Proposition	Customer Relation	Customer Segment
Investor (Grantors) Mentawai Regency NDPA RDPA R-owned Enterprises PLN Farmers Cooperatives Village Community Nursery Greenhouse O&M service co. KLHK Carbon Market	Energy Conversion Partner Management Customer Relation Management Carbon Certification Key Resources Green productivity of community bamboo forest Quality of bamboo biomass Supply chain institution of bamboo biomass	Renewable Green Energy (bamboo biomass electricity) Sustainable Welfare (lighting facilities & clean water) Rural Economic Empowerment (community forest management) ↓ Gold Standard Certified Carbon Emission Reduction (environmentally, socially & economically sustainable)	Longterm Community Co-creation (through socialization, counseling and bilateral) Channels PLN Village Community Farmers Cooperatives Carbon Market	Village Community Regency Office School House of Worship Public Health Center Public Facility Industrial Area Municipal Carbon Credit Buyer
Cost Structure		Revenue Stream		
Investment Cost (Capital Expense/ Capex) Operation Cost (Operational Expense/ Opex) + carbon certification costs		Grants/ Softloans Investment = Capex Payment from PLN (Feed in Tariff) Profit = Feed in Tariff - Opex +sale of carbon credits		

Figure 12

Biomass Energy Business Model Canvas Based on Sustainable Community Bamboo Forest