A SYSTEMIC APPROACH TO BIOMASS ENERGY DEVELOPMENT: THAILAND'S PATH TOWARDS SUSTAINABLE DEVELOPMENT

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ABSTRACT: The aim of this research is to explore the key problems of biomass policy implementation influencing stakeholders, to find out strategies to address key problems from all stakeholders, and to develop a systemic model contributing to address the key biomass problems. It was conducted within a framework of Critical Systems Thinking (CST), using a modified form of Soft Systems Methodology (SSM) [1-2] and Critical Systems Heuristic (CSH) [23] through the interview, participant observation and focus group as data collection regarding perspectives of biomass policy implementation among stakeholders. Root definitions and conceptual models were generated by participants for six-activity systems identified by them: availability of raw material; environmental management; technology development; development of transmission lines; the improvement of policy, law and regulation, and the development of investment. The findings was found that there were sixteen strategies to address biomass energy problem in six aspects. The findings contribute to both theoretical and practical contributions. As the theoretical contribution, the applications of system approach provide a significant contribution to the body of knowledge surrounding biomass energy problem solving. For the practical implications, the findings suggest sixteen strategies to address biomass problems and barriers.
Keywords: Systemic Approach, Critical Systems Thinking (CST), Soft System Methodology (SSM), Critical Systems Heuristic (CSH), Biomass Energy.

1 RENEWABLE ENERGY DEVELOPMENT: COMPLEXITY AND SUSTAINABILITY

The world has been facing increasingly severe climate change due to the increase of the greenhouse effect derived from human activity, which has influenced different countries around the world to become aware, recognize this problem and feel concerned about its potential effects [10]. The objective of the Intergovernmental Negotiating Committee for a Framework Convention on Climate Change was to control greenhouse gas emissions or GHG, which was derived from human activities and which affected global climate change [4]. As a consequence, different concepts and approaches have been developed continuously to deal with carbon emissions and other environmental harms derived from human activities issues. One of the approaches is a holistic and multi-disciplinary approach. Specifically, this approach can enable us to understand the complex linkages between climate change and energy environment closely intertwined [9].

Global fuel, food crises, overdependence on fossil fuels, greenhouse gases, global warming and climate change are the critical energy sector challenges. This occurs due to the increase of population, energy demands and the growing awareness of climate change. To move from a fossil fuel economy to an economy of renewable energy sources is a complicated process, which requires a long-term development strategy and a concerted effort to ensure its implementation [7].

Employing biomass energy is one of the alternative strategies to mitigate carbon emission and fossil energy resource usage. At present, a number of countries around the world such as Brazil, European countries and the US have developed plans and policy to increase the proportion of biomass energy consumption in order to reduce the greenhouse effect and to reduce the proportion of fossil fuel usage [15]. For Thailand, we had an improved Power Development Plan (PDP) and enacted the plan in 2015 as the national long-term energy development plan. The objective of PDP 2015 was to increase power production capacity to 57,400 MW by 2036 and reach maximum power production capacity at 70,410MW in the next 21 years. The plan intended to increase of the amount of 'cleaner fuels' and reduce reliance of natural gas. At the end of PDP 2015, the objective of the plan was to reduce the proportion of natural gas usage from 64 percent at present to between 30 and 40 percent and increase the proportion of alternative energy usage from 8 percent at present to between 15 and 20 percent. The primary goal is to increase the proportion of alternative energy usage derived from biomass power, hydropower and solar power, respectively.

Although renewable forms of energy such as biomass, solar, wind or geothermal power are proved to be better for the environment, many researchers have been arguing about problems and barriers facing alternative energy. Guardiola et al. (2009) has said renewable resources are more costly than fossil fuel technologies, in part because renewables are capital-intensive, requiring hefty initial expenditures on equipment in exchange for lower operating costs over time and tend to be undervalued by electricity producers, utility regulators, legislators and consumers. Furthermore, the main barriers to the use of biomass as fuel in commercial industries or for power generation are the high investment cost, low conversion efficiency, difficulties in transportation, seasonal dependency and moisture content [6]. In order to control the negative effects of the production and utilisation of biomass, countries need to consider not only the technological development of biomass utilisation by increasing conversion efficiency, but also technological know-how and transferral to the operators. Moreover, policy formulation, raw material supply, demand side management, user awareness and financial support all require careful thought.

In particular, the lack of links between the policymaker and all stakeholders in order to formulate an appropriate policy and planning, lack of good cooperation among government and private sectors

caused policy implementation not to be successful. Lack of practical demonstration of sustainability, lack of effective participation and lack of public acceptance [11] have been presented to be the key issues in association with Thailand biomass generation. This research, therefore, is aimed to study problems and barriers hindering biomass power generation in Thailand and find out appropriate strategies to address biomass problems and barriers sustainably in the future.

2 WHY WAS A SYSTEMIC APPROACH RELEVANT FOR BIOMASS ENERGY INTERVENTION?

Energy environment and climate change are closely intertwined. A holistic and multi-disciplinary approach is needed to understand the complex linkages between them [9]. Global fuel, food crises, overdependence on fossil fuels, greenhouse gases, global warming and climate change are the critical energy sector challenges, due to the increase of population, energy demands and the growing awareness of climate change. Problems and barriers related to energy are complex in nature, as it has a direct and an indirect impact across diverse sectors. To move from a fossil fuel economy to an economy of renewable energy sources is a complicated process, which requires a long-term development strategy and a concerted effort to ensure its implementation [7]. Therefore, it is essential to see energy holistically and systematically linked with a range of issues rather than an isolated sector. This study argues that the systems approach is relevant for energy development. It is the theoretical framework best suited for addressing the complex problems and barriers of biomass energy, so as to find the best negotiable strategies with a view of sustainability of the whole system.

Regarding energy and its links to complex problems, the implication of these links is that the issue of energy has to be tackled in such a way that other problems are not aggravated. Conventional energy strategies, which focused mainly on energy efficiency, the supply and demand side, do not tend to address complex problems and barriers. There need a holistic approach that integrates social, economic and environmental issues to determine the sustainability of the bio-energy systems. According to Jackson (2000), holism does not seek to breakdown complex problem situations into their parts in order to study and intervene in them; rather, it respects the interconnectedness of the parts and concentrates on the relationships across them and how these often give rise to surprising outcomes in emergent properties. In support of this statement, holistic thinking is useful for understanding the nature of the problem and for working out negotiated ‘solutions’ [8]. Systems thinking use models rather than experiments in the laboratory in attempts to understand the nature of the problem. It also does not impose any arbitrary boundary between the subject of attention and the environment in which it is located. Rather it reflects and questions where the boundary has been drawn and how this impacts the kind of improvement. This provides the opportunity to explore and analyse the complex problems and issues linked to energy in more depth. This is the reason that it is relevant to use a systemic approach in the study of biomass energy intervention addressing problems and barriers.

3 AIM AND RESEARCH OBJECTIVES

The aim of this research is to develop a systemic model that can influence the decision-making by the government to enact public policy that will encourage all stakeholders to participate in alternative energy sources. The specific objectives are as follows:

1. Investigate the current situation of the alternative energy policy in Thailand
2. Explore the key problems of biomass policy implementation influencing stakeholders and find out strategies to address the key problems.
3. Develop a systemic model that can contribute to address the key biomass problems and
4. Assist the government’s decision to improve the existing institutional context for efficient biomass policy implementation.

4 RESEARCH METHODOLOGY

In order to achieve the research aim and objectives, the interpretivist paradigm was applied to examine complicated situations [17]. A qualitative approach was adopted to seek the data and gain an insight to understand energy situations. This research was applied participatory action research (PAR) as the appropriate strategy and grounded in Critical Systems Thinking (CST). The approach used was one of mixing methods: specifically, the creation of a relationship between Soft Systems Methodology (SSM) [1][2] and Critical Systems Heuristic (CSH) [23]. Semi-structured interview, participant observation and focus group were conducted with seven policy-makers from the government sector, seven scholars from the academic sector, four representatives from NGOs, and nine representatives from two biomass power plants, to build up a rich picture of the biomass situations. Afterwards, workshops were held to identify and model relevant systems and generate strategies for change.

The research findings were analysed in terms of biomass key problems and barriers, and applied to be the strategies for sustaining problem-solving in biomass energy development in the future. The data analysis process was based on systems thinking theory with participatory action research (PAR), which is grounded in Critical Systems Thinking (CST). Semi-structured interviews, focus groups and participant observation were used to collect the data in every process among stakeholders. Within the conceptual framework (Fig. 1),

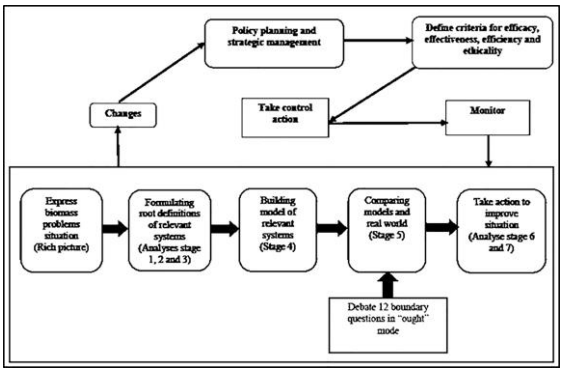

Figure 1: Conceptual Framework
Source: [13]

In the workshops, the seven stages of SSM were presented with the participants as the framework of discussion. It began with identification and expression of the problematic situation in stages one and two of SSM. This stage dealt with discussions about the rich picture of biomass problems and barriers and the relationship between them. On the basis of the information obtained in stages one and two, together with reflection on systems methodologies, SSM was chosen as it embodies an interpretivist approach in which multiple perceptions are acknowledged and explored, and values made explicit. This makes it a useful approach for pluralist problem contexts, or "problematic situations" as [1][2] prefer to call them. In these stages, expressed information is gathered about relevant structures and processes and in order to generate a "rich picture" of the situation. The idea is that this highlights significant and contentious aspects in order to stimulate creative understanding. For this stage, the rich data carried forward into the workshops from the interview phase provided a starting point. This material was extensively debated and expressed in a variety of diagrammatic forms, in order to capture the issues of concern to participants.

In stage three (Relevant Systems), participants selected relevant systems for issues they considered important. These are abstract and artificial in nature; they do not necessarily correspond with actual systems existing in the real world, but are described as systems to aid thinking about the way activities are linked and impact on each other. To ensure completeness of the definition, the CATWOE mnemonic is used:

C: Customers – those who use/benefit from the system
A: Actors – those who perform the activity in the system
T: Transformation – what the system does
W: Weltanschauung (World view) – values, beliefs, assumptions
O: Owners – those who control (have power over) the system
E: Environment – facilitators and constraints

Systemic models were developed in stage four, each activity with a significant verb, structured in a logical sequence, and reflecting the minimum activities needed to achieve the transformation indicated in the root definition. The idea of conceptual modelling is to produce a description of the actions needed to carry out the transformation and other requirements of the root definition. At this stage, the focus is on what participants think should be in the system, irrespective of whether or not it already exists or how well it is done. Lists of activities are arranged in a diagram which captures contingent relationships among them. In stage five, the conceptual model was compared with the real world based on the opinions of the participants. In this stage, the researcher applied 12 boundary questions in the 'ought' mode [14] as the guidelines for discussion. The last session in the workshop was a discussion for stages six and seven, which was focused on agreeing and implementing change. Any changes must be both socially desirable and systemically feasible.

5 RESEARCH FINDINGS

This research was carried out within an overarching framework of Critical Systems Thinking (CST), using a modified form of Soft Systems Methodology (SSM) and Critical Systems Heuristic (CSH) to deal with the key biomass problems and to find out strategies to address key problems. Root definitions and conceptual models were generated by participants for six activity systems identified by them for attention (see figure 1): availability of raw material; environmental management; technology development; development of transmission lines; the improvement of policy, law and regulation, and the Development of investment. The findings were found that there were sixteen strategies to address biomass energy problem in six aspects.

Stage 1: Enter situation considered problematic

In this stage, I had explained the research objective and guidelines of the study to the participants, including the introduction of focus group procedure based on the seven stages of SSM. After that, I encouraged participants to discuss the current situation of biomass energy in Thailand. NGO representative NG4 pointed out that "in order to consider biomass energy, The government had to consider its origin, which was in agricultural production, growing areas, plant category potential for production, growing methods, soil and water quality including the growing season. These all influence agricultural yield and its waste became biomass raw materials, which fluctuate. These raw materials included rice husk and wastes of sugar cane, palm and wood. We knew where growing areas were, but we lacked clear data of remnants used as biomass raw material each year, because data update was not continuous". Next, Academic sector (AC8) said "we had to consider how to collect and transport biomass raw materials to the production process, which was concerned with processes of collecting, preparing and compacting raw materials prior to transporting them to a stream turbine boiler. The step prior to the electric generator process was also critical, because it related to technology, most of which was imported from China or Germany. We still lacked local technology development, which required much investment. Private sector, then, had to consider the power production process, which required an ESP machine, ventilator and ashes collector, which could prevent environmental effects on nearby communities. In addition, for the post-production process, we considered the economic and social impacts on the local people living near the power plant". The government officer G7 agreed with the NG4's idea of that biomass energy development deal with early consideration as raw materials. He said "that biomass raw material was actually dealt with by the policy of the Ministry of Agriculture and Cooperatives. After agricultural cultivation, the yield and growing area were under the authority of the Ministry of Agriculture. In the past, the Ministry of Energy had announced ten major crops, and biomass plants came last; the previous government had promoted growing Napier grass as a biomass raw material and it was ranked as the last priority in the next government. It was obvious that this policy from the ministry highly and directly influenced the quantity or supply of biomass raw materials. In the past, the Ministry of Agriculture simply informed the Ministry of Energy of the agricultural area allocation, but cooperation between the two ministries in terms of policy determination was not good enough. That was why their policies were not working harmoniously". Further to raw material shortages, G7 had the same opinion as the other stakeholders about the uncertainty of biomass raw material quantity. He said "the uncertainty of raw material arose because DEDE was not funded for

studying the potential of biomass raw material in each aspect. Therefore, they lacked essential data required to determine policy and plan. Formerly, DEDE applied data from the Department of Agricultural Economics to develop a plan. The problem of biomass raw material was that we did not know the exact quantity of the remnant; yield fluctuated in different seasons and so did the agricultural yield market price. This made the raw material quantity uncertain". In addition, NG4 agreed with G7 that "lacking of clear data of biomass raw material directly influenced planning. Although we had studied the sources of raw material prior to the plant construction, we lacked insight data. We just had rough data, so the estimation of the raw material supply in an area was not clear, and lacking sufficient data from the government generates risk for entrepreneurs in the future". AC8 added that "each environmental problem related to each other, including raw material collection and transportation. It was said that environmental problems happened from the beginning to the production, such as dust. On power purchasing policy, stakeholders thought that FiT was more suitable than the adder price system, because adder provided a short contract period of about seven years, while the feed-in tariff price system covered more than 20 years in its contract". In terms of income, feed-in tariff generated more income than adder because adder granted a fixed price, but feed-in tariff generated two prices: a fixed price based on investment; and a variable price based on the raw material price. During the transaction period, existing entrepreneurs already holding the adder contract were affected. There were some advantages against existing and in favour of new entrepreneurs. In this case, the government was expected to prepare some measures to manage the change.

Stage 2: Express the problem situation

In the second stage, I and stakeholders participated in a focus group and designed the relationship picture of Thailand's biomass power generation to be applied in discussion on 'Problems and Barriers of Biomass Energy in Thailand'.

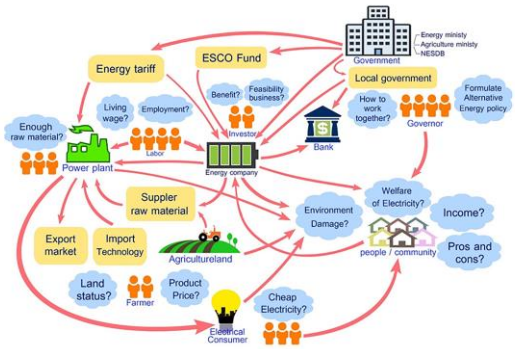

Figure 2: Rich picture of biomass power generation in Thailand
Source: [13]

Fig. 2 shows the rich picture analysis of biomass energy in Thailand, focusing on its problems and barriers. In this stage, participants in the focus group had shown their comments about the current situation of biomass power production. Discussion of the biomass problems and barriers followed, which summarized the important problems and barriers of biomass power into six important issues. These are raw material shortages; problems in terms of policy, law and regulations; difficulty of access to financial investment; inadequate transmission lines; lack of continuous improvement or development of technology; and environmental problem. After discussing these problems, it was agreed it is of vital importance to solve in the future.

Stage 3: Formulate root definitions of relevant systems

This is a critical step in the SSM. The root definition is a statement of purpose that captures the essence of the particular situation of the relevant system. At the heart of the root definition is the transformation that is performed by the relevant system. Further to the above-mentioned problems, in this section, participants in the focus group agreed to consider six systems, including availability of raw materials, environmental management, technology development, development of transmission lines, effective policy, law and regulation improvement, and consideration of access to investment. Definition is presented and checked against the CATWOE mnemonic as below.

Root definition 1: Availability of raw material

As seen in Table I, cooperation between the ministries of Energy and Agriculture to determine biomass energy policy and plan in term of determination of energy crops growing area and apparent price of different raw material will help reduce risk of entrepreneurs and power plants in term of raw material shortage; and reduce the fluctuation of raw material cost which make them able to manage their production more effectively.

Table I: CATWOE analysis of root definition (RD1) – Availability of raw material

C	Customer		Private sector/power plant
A	Actors		The Ministry of Energy and Agriculture
T	Transformation	-	- Increase the effectiveness of cooperation between the ministries of Energy and Agriculture in determining biomass power policy and plan - Determining energy crops growing areas - Enactment of different biomass raw material price
W	Weltanschauug	-	- Sufficient raw material will make planning more stable and effective - Clear raw material pricing helps reduce private sector's

			cost fluctuation and production costs
O	Owners		Ministry of Energy and Ministry of Agriculture
E	Environment	-	- Attitude towards good cooperation between the ministries of Energy and Agriculture - Cooperation of government sector and local citizens in determining energy crops growing area

Root Definition 2: Environmental Management

Following Table II, strict law enforcement along with environmental monitoring plan for biomass power plants by the Ministry of Energy, and natural resources in charge of pollution control department will help supervise effective environmental management of biomass power plants and local citizens. In addition, the increase of participation by local people near the power plant and support for community development fund with good participation between the power plant and local citizens can definitely create good understanding, community development and accountability towards environment.

Table II: CATWOE analysis of root definition (RD2) – Environmental management

C	Customer	Local citizens nearby the power plant
A	Actors	Energy Regulatory Commission
T	Transformation	- The increase of local citizens' participation with EIA and EHIA to provide acceptable data among concerned parties - The government should provide additional data and knowledge about alternative energy to the general public i.e. through a website or printing media. - Provision of environmental evaluation at biomass power plants every three months and strict pollution control law enforcement. - The establishment of community development fund near the power plant with good cooperation among the entrepreneur and local citizens.
W	Weltanschauug	- Strict and effective environmental control law enforcement - Participation by local people near the power plant with investigating, monitoring and evaluating environmental management of the power plant. - The increase of participation between the power plant and local citizens with environmental awareness and reservation.
O	Owners	Ministry of Energy and Ministry of Natural Resources and Environment
E	Environment	- Attitude of people nearby the power plant and their concern toward environmental effects. - The trust of entrepreneur and local citizens

Root Definition 3: Technology development

Following Table III, research and development of technology to produce biomass power and technology to collect raw material under the cooperation of government and private sectors and institutes will help power plant entrepreneurs to utilize local technology, reduce production costs and import, and increase the capacity of domestic organizations to study, research and develop technology consistently for the sustainable alternative energy development in the country.

Table III: CATWOE analysis of root definition (RD3) – Technology development

C	Customer	Private sector/biomass power plant
A	Actors	- The Ministry of Energy - Institutes - Power plant entrepreneurs
T	Transformation	- Research and development of technology for power plant production and raw material collection with cooperation among government, private sectors and institutes. - The government provides financial support for consistent research and development to potential institutes and private sector. - Motivating measures for more technology development in the country such as tax reduction, different sponsorship for potential

		private sector or institutes
W	Weltanschauug	- Increase the capacity of local technology research and development. - Reduce technology import. - Reduce biomass power production cost.
O	Owners	The Ministry of Energy, institutes and power plant entrepreneurs.
E	Environment	- Attitude towards power production technology of the entrepreneurs (trust and reliability) - Attitude towards co-working among government and private sectors and institutes.

Root definition 4: Development of transmission lines

Following Table IV, throughout the development of transmission lines, particularly in the areas with potential for producing biomass power, which requires co-planning between EGAT and the Ministry of Energy and will generate confidence among entrepreneurs in investing into alternative energy and increase the effectiveness of the country's power transmission system in the future.

Table IV: CATWOE analysis of root definition (RD4) – Development of transmission lines

C	Customer	Private sector / biomass power plant
A	Actors	EGAT and Ministry of Energy
T	Transformation	- The Ministry of Energy and EGAT need to work together to develop a plan for transmission lines throughout, particularly for potential areas for producing biomass energy.
W	Weltanschauug	- There will be development of a smart grid in the future (a good power production, enough transmission lines and efficient for the system and usage). - The government sectors will provide correct data and information about locations of the transmission line system along with data about technology utilization in order to support the entrepreneurs.
O	Owners	EGAT and Ministry of Energy
E	Environment	- Attitude of co-working between EGAT and Ministry of Energy in planning transmission lines.
		- Relative to the Building Control act, C.E. 1979

Root definition 5: the development of effective policy, laws and regulations

According to Table V, an effective improvement of power purchasing policy that takes into account real production costs, which are different in each area, and revision of law and regulations concerning it can reduce redundancy. This requires working together and sharing responsibility between the ministries of Energy and Industry in order to support entrepreneurs in the biomass power plant industry with a power purchasing policy based on real costs. In addition, it can reduce the redundancy of different regulations, which are time consuming when applying for power plant construction approval.

Table V: CATWOE analysis of root definition (RD5) – the improvement of policy, laws and regulations

C	Customer	Private sector/biomass power plant
A	Actors	Ministry of Energy and Ministry of Industry
T	Transformation	- The establishment of a one-stop service for power plant construction approval, permits for factory operation (Ror Ngor 4 Form) and EIA and EHIA evaluations. - The improvement of power purchasing policy, which complies with real production cost that are different in each area. - The improvement and revision of redundant law and regulation.
W	Weltanschauug	- Biomass power purchasing policy, which complies with the real production cost. - Reduce time for the application procedure - Reduce the corruption
O	Owners	Ministry of Energy and Ministry of Industry
E	Environment	- Political attitude - Conflict of interest

Root definition 6: the development of capital access

Following Table VI**,** provision of good knowledge and understanding about alternative energy for financial institutes along with the guidelines of investment loan approvals for private power plant construction and the increase of the ESCO Fund, managed by the Ministry of Energy, will make entrepreneurs in the biomass power industry have more choices and opportunities to access their investments, particularly for small entrepreneurs who have potential but lack the necessary investment for biomass power production.

Table VI: CATWOE analysis of root definition (RD6) – the development of capital Access

C	Customer	Private sector/biomass power plant
A	Actors	Ministry of Energy, NGOs (ESCO Fund)
T	Transformation	- The government must provide knowledge and understanding about alternative energy development in the country to different financial institutes in Thailand along with guidelines to approve investment load for private power plants. - Increase support funds to support alternative energy development and ESCO Fund.
W	Weltanschauug	- The financial institution has a good understanding and more confidence with the power plant project - Private sector have more choices to get access the financial
O	Owners	Ministry of Energy
E	Environment	- Attitude from the workers at the financial institution

Stage 4: Build conceptual model

This stage is intended to develop conceptual models to explain the way to create change based on data from stage 3, which is needed to carry out the transformation and other requirements of the root definition. This stage focuses on opinions of participants in the focus group regarding what they think should be in the system, irrespective of whether or not it already exists or how well it is executed. The next step is to produce a list of activities by connecting the relationship of each activity in diagrams, shown by the direction of the arrows. The conceptual models derived from a root definition consisting of six systems, including availability of raw material, environmental management, technology development, development of transmission lines, improvement of policy, laws and regulation, and investment access as shown in Figures 3,4,5,6,7 and 8, respectively.

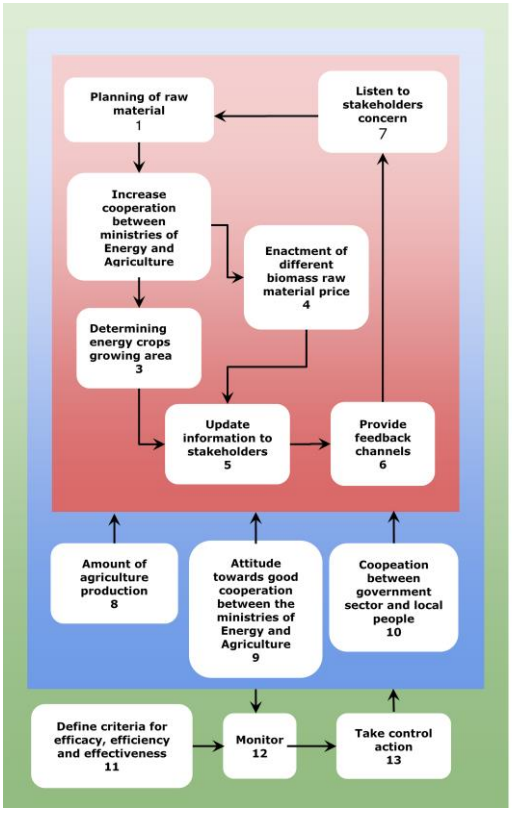

Figure 3: The conceptual model of availability of raw material

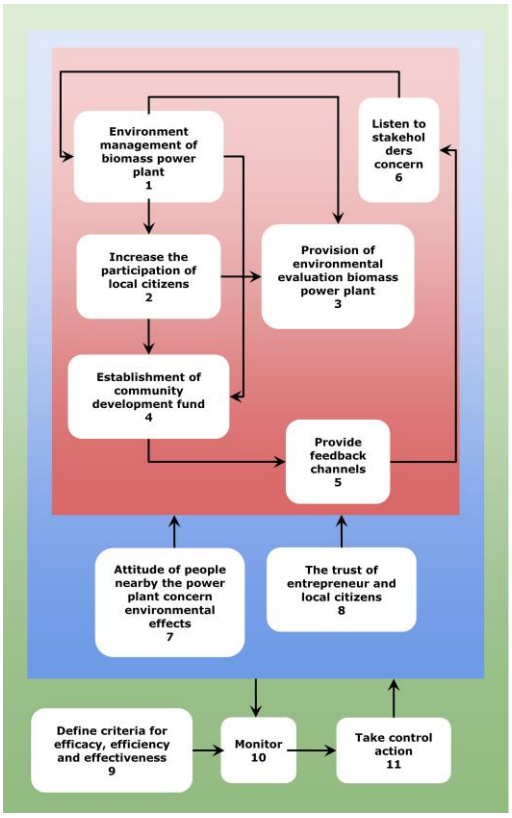

Figure 4: The conceptual model of environmental management

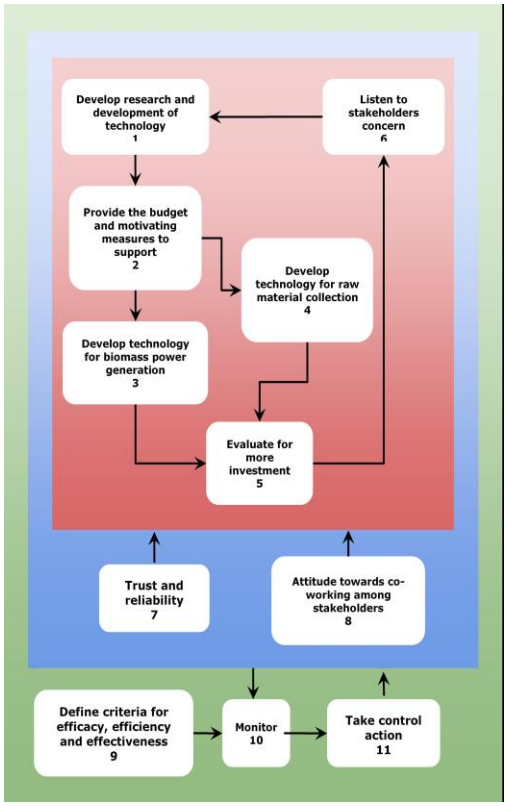

Figure 5: The conceptual model of technology development

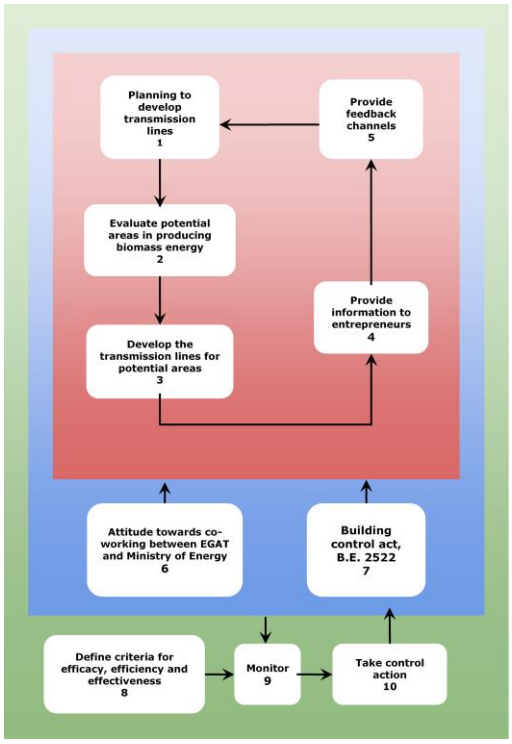

Figure 6: The conceptual model of development of transmission lines

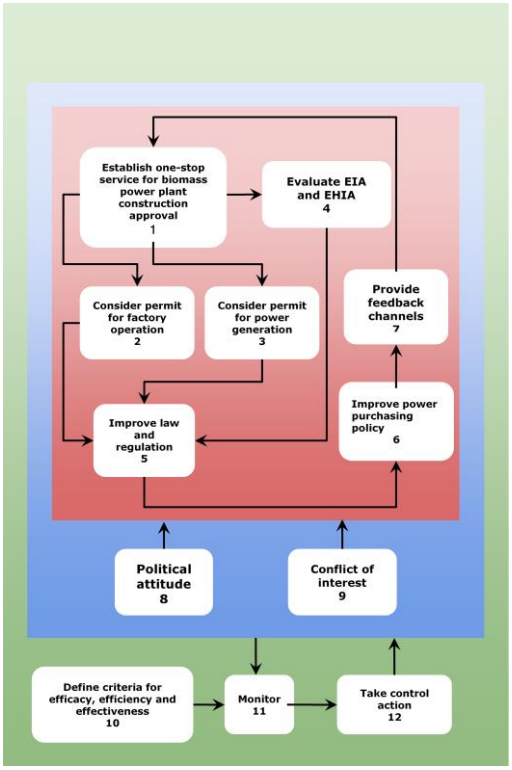

Figure 7: The conceptual model of the development of effective policy, law and regulation

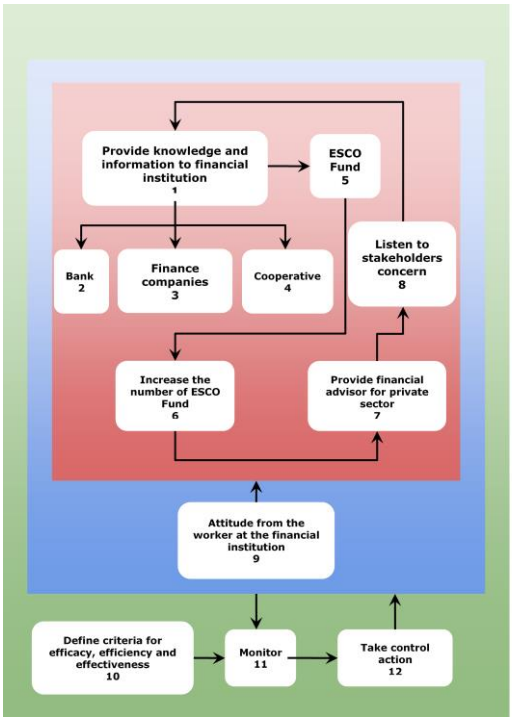

Figure 8: The conceptual model for the development of investment

Stage 5: The comparison of models and the real world

In this section, I had applied the 12 questions of CSH in 'ought' mode discussed with participants. This stage presented the comparison of conceptual models from stage 4 and the real world. The purpose of the

comparison is to initiate discussion from which changes to improve the situation can be identified. I summarized the discussion with stakeholders in Table VII. The first column of the table shows the activities in the conceptual model. The second column presents the real world, and the third one presented what we can do to bring reality closer to the logically defensible conceptual model.

Table VII: Conceptual model – real world comparison table

Conceptual model activities	**Real world**	**What could we do**
1.The consideration of raw material sufficiency	1. Cooperation between the ministries of Energy and Agriculture in terms of determining energy plant growing areas that are not effective enough. 2. Determination of lack of energy plant growing areas. 3. Standard purchasing price for biomass raw material has not been determined yet.	1. Increase the effectiveness of cooperation between the ministries of Energy and Agriculture in determining biomass power policy and plan. 2. Determining biomass power plant growing areas. 3.Enactment of different biomass raw material prices.
2. Improvement of environmental management effectiveness	4. Participation with environmental impact evaluation and health of local citizens was still limited, and most local citizens have no good understanding of biomass power production, which leads to objections against power plant construction in many areas. 5. Environmental impact evaluation and law enforcement is not strict enough. 6. Local people in the area and power plant entrepreneurs lack of good cooperation with the overall power plant management.	4. The increase of local citizens' participation with EIA and EHIA to provide acceptable data among concerned parties. 5. The government should provide additional data and knowledge about alternative energy to general public, such as website or print media. 6. Provision of environmental evaluation at biomass power plants every three months and strict pollution control law enforcement. 7. The establishment of a community development fund for the community near the power plant with good cooperation among the entrepreneur and local citizens.
3.Technology development	7. We lack consistent technology development because we have not obtained substantial budget support and supportive measures by the government.	8. Do research and development of technology for power plant production and raw material collection with cooperation between government and private sectors and institutes. 9. The government provides financial support for consistent research and development to potential institutes and private sector. 10. Develop motivating measures for more technology development in the country, such as tax reduction, and different sponsorship for potential private sector or institutes
4. Development of transmission lines	8. Many areas with potential for producing biomass power do not have effective and sufficient transmission lines and infrastructure.	11. The Ministry of Energy and EGAT need to work together to develop a plan for transmission lines throughout, particularly for potential areas in producing biomass energy.
5. The	9. Different	12. The

improvement of policy, law and regulation	permits for power plant construction consume much time and have complicated process or procedure. 10. The existing power purchasing policy for biomass energy is the same throughout the country and it is not possible to classify difference of each area.	establishment of one-stop service during power plant construction approval, permits for factory operation (Ror Ngor 4 Form) and EIA and EHIA evaluations. 13. The improvement of power purchasing policy, which reflects real production costs that are different in each area. 14. The improvement and revision of redundant laws and regulations.
6. The Development of Capital Access	11. Most financial institutions in the country lack knowledge and understanding about alternative energy, which directly influences investment loan approval for the entrepreneurs. 12. Channels to access financial investment by biomass power plant entrepreneurs is limited.	15. Government sector must provide good knowledge and understanding about country alternative energy development to different financial institutes in the country along with the guideline to approve investment loan for private power plant construction. 16. The government must increase ESCO fund.

Stages 6 and 7: Agreeing and implementing change

Table VII, as proposed above, shows the comparison of conceptual models and the real world in term of suggestions made by the participants for what might be developed and resolved, based on the current situation of biomass energy. In this section, I had summarized the strategies to address biomass energy problems and barriers (see Table VIII)

Table VIII: Summary of strategies to address biomass energy problems

Biomass problems and barriers	**Strategies to address the key problems**
1. Availability of raw material	1. Integrating the cooperation among government sectors, especially the cooperation between the Ministry of Energy and the Ministry of Agriculture and Cooperatives in developing biomass energy policy and plans, allocation of biomass power plant growing areas, and price determination for different types of biomass raw material. 2. The study of potential and area determination for biomass power plants. 3. A clear announcement of regulations or procedures to determine purchasing price for different types of biomass raw material.
2.Environmental management	4. The increase of public participation in the EIA and EHIA process. 5. The government should provide the knowledge and the key information about alternative energy to local people. For example, a website or printed media will provide data and allow people to access the data easily. 6. Consistent and complete evaluation of environmental management at the biomass power plant along with strict enforcement of pollution control law and regulation. 7. Establishment of a community development fund for the area around the power plant under the cooperative management of the entrepreneur and local people.
3.Technology development	8. Do research and development of biomass power generation and the development of harvesting raw materials technology through the cooperation between government sector, private sectors and educational institutions. 9. The government provides financial support for consistent research and development to potential institutes and private sector. 10. Develop motivating measures for more technology development in the country, such as tax reduction, and different sponsorship for potential private sector or institutes
4. Development of	11. The Ministry of Energy and

transmission lines	EGAT should collaborate on planning power transmission lines development throughout the area, especially for those areas with the potential to produce biomass energy, along with up-to-date information about transmission lines for the entrepreneurs.
5.The improvement of policy, law and regulation	12. Establishment of a one-stop service centre for approve power plant licenses (Ror Ngor 4 license), EIA and EHIA evaluations in order to reduce time to process. 13. The improvement of power purchasing policy, which reflects real production costs that are different in each area. 14. The improvement and revision of redundant laws and regulations.
6. The development of investment	15. The government must provide knowledge and understanding to local financial institutions, so that they are confident about the national alternative energy development, along with the guidelines to approve investment loans for power plant construction. 16. Increase in the alternative energy development fund and efficiency fund (ESCO Fund).

6 CONCLUSION AND RECOMMENDATIONS

Although the government emphasised alternative energy development by enacting different laws and regulations, developing alternative energy policies and plans, developing infrastructures and supporting funds to increase power generation and consumption of alternative energy in Thailand. However, the development of alternative energy in Thailand was moving slowly, especially for biomass energy, which was an important source of alternative energy in the country. Even though the government had tried to solve the problems by revising energy policies and plans and presenting different measures such as the revision of PDP 2015 into PDP 2018, along with changing power purchasing policy from Adder to FiT, and the improvement of cooperation among government sectors, but the development of alternative energy was not successful. In this study, the findings revealed major reasons why the alternative energy development was not successful. The problems and barriers of biomass energy in Thailand consisted of six different types; availability of raw material; environmental management; technology development; development of transmission lines; the improvement of policy, law and regulation, and the Development of Capital Access. And the findings from the interviews and workshop showed 16 strategies to address six main issues of biomass energy problems (as discussed in Table VIII).

Moreover, it was found that many research studies the problems and barriers of biomass energy were different based on the location, potential of raw material, technology, policy, laws and regulations, potential of private sectors and public acceptance, which made the research into the problems and barriers of biomass energy. Each research study aimed to find out strategies to address the key problems hindering biomass energy to increase the effectiveness and proportion of biomass energy consumption [9][12] [15]. However, it was known that the application of a systemic approach to deal with problems and barriers of biomass energy along with the appropriate strategies to address the key problems was relatively rare since there were very few researchers using systemic approach to study renewable energy. Therefore, the findings and approach of this study could be considered novel. The theoretical contributions to knowledge provided by this research could be considered as three main methods. Firstly, the application of systemic approach to address problems and barriers of biomass energy as the appropriate guideline to solve biomass energy problems in Thailand sustainably makes a contribution. Secondly, another innovation is the application of SSM and CSH to structure the process of gathering information from stakeholders in all sectors to address biomass energy problems in Thailand. Lastly, findings from the research could be applied to develop a new model of power generation from biomass as the strategies to develop biomass energy in Thailand sustainably.

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