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Institutional Analysis on Palm Oil-based Bioenergy for Rural Community Electricity Development in Indonesia: A Hybrid of Soft System and Hard System Approach

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Abstract

The program of palm oil-based bioenergy development and utilization is one solution that can be applied to meet the electricity needs of the rural community in Indonesia. However, various needs and obstacles faced by related stakeholders have caused the program to not be implemented. The objectives of this study were to identify institutional issues that begin with identifying the needs and fundamental issues of program implementation, to identify key elements of the program's success, and to the determination of an adaptive institutional model. A total of 12 experts were involved and provided an assessment. The analysis was performed with the implementation of the seven stages in the Soft System Methodology. To get more structured and measurable analysis results, the analysis was also supported by Hard Systems Methodology techniques, such as the Interpretive Structural Modeling and Fuzzy Analytical Hierarchy Process. The result of the study obtained 7 key sub-elements, consisting of 3 sub-elements in the program needs element, 1 sub-element in the major constraint element, 1 sub-element in the objective element and 2 sub-elements in the supporting factor element. The study also gained and adaptive institutional model that plays a role in the provision of raw materials, infrastructure construction, energy transformation, operational and management, distribution and commercialization of electricity to rural communities.

Keywords

bioenergy, institutional, palm oil, Soft System Methodology (SSM), Hard System Methodology (HSM)

1 Introduction

The provision of electricity in sufficient quantities with good quality and reasonable prices is still a fundamental problem in several regions in Indonesia. In Indonesia, electricity is generally supplied by the State Electricity Company (SEC). SEC plays an important role in supplying electricity to various sectors and needs, among them to household, industrial, government buildings and street lighting. However, the shortage of power supply still frequently occurs that causes electric voltage instability and even frequent power outages in turns. This condition can disrupt the various activities of people's lives that are dependent on the availability of an electricity supply at all times. In addition, other obstacles such as difficult location, regulatory and policy issues, land acquisition, licensing process, legal issues and coordination across sectors, have denied some areas, especially in rural areas an electricity supply from SEC (Directorate General of Electricity, 2016).

Currently, although nationally there has been an increase in the ratio of electrification, in fact not all regions in Indonesia have received a proper electricity supply, one of which is in the Riau Province. In this area, although the electrification ratio has been above the national average, there are still many rural areas that have not reached SEC. Until 2016, the number of subscribers that have been powered by SEC electricity in the Riau Province is 1,211,259 customers, of which 89.82 % are household customers. Of the 12 districts, only 3 of them have an electrification ratio above average, such as Kuantan Singingi,

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Pekanbaru and Dumai (BPS, 2016). Furthermore, of the total 1,829 villages in the Riau Province, as many as 1,569 villages have been connected to the electricity network, while 263 villages (14.37 %) do not have the electrical network ratio (Enreach, 2016).

This condition needs to be the concern of all stakeholders, especially from central government, local government and the private sector. Anticipation should be done immediately, one way through the utilization of new and renewable energy potential. One of the most potential new and renewable energy sources is palm oil waste. Today, the plantation and mill wastes such as empty fruit bunches of oil palm, fiber, shell and liquid waste, has the potential to be used as a source of electrical energy (bioelectric).

The palm oil industry has considerable electrical energy potential. A study shows that at a palm oil plant with a production capacity of 30 tons of Fresh Fruit Bunches (FFB) per day, it has the potential to generate 20 to 25 MW of electrical energy. This potential can be used as a source of energy at the plant and even produce an excess of 1,885 MJ or equivalent to 530 kW for 1 ton of FFB (Ansori Nasution et al., 2014).

Indonesia has the potential of palm oil biomass, which is very large, to be used as an alternative energy source. Nevertheless, despite efforts to use this, it is not maximized. It is evident, from the total energy potential of oil palm plantations in Indonesia, which amounted to 12,654 MWe, only 3.5 % or 450 MWe that have been utilized (Directorate General of New Renewable Energy and Energy Conservation, 2016). The utilization of palm oil biomass (palm waste and POME) as a source of electrical energy, has been developed by 15 large companies in Indonesia, 3 of which are in the Riau Province (Directorate General of New Renewable Energy and Energy Conservation, 2016). The generated electricity supply has been supplied on-grid through SEC's power grid to the community.

The Riau Province is the largest producer of palm oil in Indonesia. Suitable land and environmental conditions cause the palm oil to thrive in all districts in the Riau Province. In total, until 2017 it was noted that the area of oil palm plantations in the Riau Province reached 2,493,176 hectares or 21.1 % of the total area of oil palm plantations in Indonesia (Directorate General of Estate Crops, 2017). Until 2015, it had stood as many as 225 palm oil mills in the Riau Province. Then, from the total potential of palm oil biomass in the region, it is theoretically estimated to produce 55,895,112.6 Gj of energy. This considerable potential, estimated theoretically can also generate electrical energy of 15,526,420.1 MWe per year (Papilo et al., 2017).

The Indonesia Government continues to realize the fulfillment of electricity needs for rural communities through various plans and programs, starting from the preparation of bioenergy development policy, cooperation with various stakeholders, to the provision of budget development of power plant based on palm oil biomass. However, various obstacles and problems have caused the plan and the program to not be realized maximally.

This study seeks to identify the underlying problems related to the biomass utilization of palm oil yet to meet the electricity needs of society, especially those in rural areas. It attempts to investigate issues in terms of institutional governance involving various stakeholders consisting of government, oil palm plantation and processing companies, energy development companies, State Electricity Companies, communities, and other relevant parties. This study is expected to be the basis for developing an adaptive institutional model in meeting the electricity needs of rural communities.

In this study, analysis and synthesis are done by integrating Soft System Methodology (SSM) with existing techniques in the Hard System Methodology (HSM) approach. SSM is an approach of soft system thinking which has been developed by Peter Checkland (Checkland, 2000). Through this approach, identifying and mapping the problems in each stakeholder is done by applying seven stages of analysis. Meanwhile, HSM is a methodology that utilizes numerical techniques and operational research through a critical system thinking (Eriyatno, 2013). HSM techniques such as Interpretive Structural Modeling (ISM) and Fuzzy Analytical Hierarchy Process (F-AHP) are used to get more structured and measurable results of analysis and synthesis.

2 Literature review

2.1 Concept of institutional

The institution is essentially interpreted as a relationship of roles and responsibilities among stakeholders which includes two important aspects among others:

1. norms and conventions; and
2. rules.

Institutions are sometimes formally formulated and carried out by the government, but are also sometimes not formally written as in the rules and norms of the community (Arifin, 2005). Organization by its form is seen as more is concrete with a more modern management

(Syahyuti, 2002). Institutions are seen as more traditional, where institutions do not have members but only consist of followers. The organization, on the other hand, is seen as more modern and part of an institution (Uphoff, 1986).

However, despite the existence of an institution, many are not given the broadest possible benefits, both for the people or for groups or other institutions because of the lack of a proper implementation of the strategy. Syahyuti has identified that there are at least nine causes of failure in the application of institutional concepts, among others:

1. institutions are built only to strengthen horizontal relationship ties without prioritizing vertical relations,
2. institutional existence more directed to the span of control organization or program implementer and not to increase the social capital of society fundamentally,
3. management structure built relatively more uniform and sometimes tend not relevant to existing needs,
4. the existence of inequality in coaching or involvement of every individual or group that exist in institutional development which leads to loss of benefits of social learning approach,
5. institutional development that prioritizes structural aspects and weakness of the culture development side,
6. the dominance of materialistic cultural interest,
7. the occurrence of a disharmony within the existence of institutional internal changes that destroy previously established horizontal relationships,
8. the dominance of the political aspects that defeat the interests of the field, and
9. the pattern of development is more sectoral, resulting in the lack of inter-institutional integration that is linked (Syahyuti, 2002).

Various researches related to the institutional model have been carried out in various scopes, including agriculture especially food crops (Ikatrinasari et al., 2009; Kusnandar et al., 2013; Saptono et al., 2010), in the field of plantation such as sugar palm plantation (Lolowang, 2012) in palm oil-based bioenergy sector (Dharmayanti, 2015; Papilo and Bantacut, 2016) and in bioenergy (Genus and Mafakheri, 2014; Udayana et al., 2010). Institutional models offered are also diverse in the form of a combination of farmer groups, non-bank institutions, holding companies, or in the form of industrial clusters.

2.2 Concept of Soft System Methodology (SSM) and Hard System Methodology (HSM)

Soft System Methodology (SSM) was first developed in the 1970s by Peter Checkland at Lancaster University, UK (Mehregan et al., 2012). SSM is an approach in a systemic study through the use of system models. SSM can provide the key techniques and basic theory that it is important to identify and define a problem and at the same relevancy explore interrelationships of system components in a broader conceptualization (Bunch, 2003).

SSM is a holistic approach in solving a complex and unstructured problem (Eriyatno, 2013). In solving an unstructured problem, a systemic thinking approach (system thinking) is required which can see the interconnection aspects of activities undertaken by various stakeholders, ranging from input level to output. The thinking system includes the process of thinking with a goal, the result and the target that is in mind, which includes the interaction of the elements, components, and subsystems as the forming of a system. In contrast to other methods included in HSM, such as system engineering or operational research, the emergence of SSM is due to the realization that the purpose of a system to be built is problematic, that is, full of obscurity (Purnomo, 2012). SSM is an approach through the application of seven steps as shown in Fig. 1.

Many researchers from various fields have used SSM as a method or approach. The use of SSM, such as in the field of management and administration of education (Mehregan et al., 2012; Soemartono, 2014), engineering products, innovation and service system (Novani et al., 2014; Presley et al., 2000). SSM has also been used in management and organizational studies (Wang et al., 2015), human resource development (Fadhil et al., 2017), improvement of organizational performance (Liu et al., 2012), security performance (Sgourou et al., 2012) and organizational policy (Henggeler Antunes et al., 2016). In addition, SSM has also been used in dealing with environmental issues (Bunch, 2003; Nidumolu et al., 2006).

In this study, the analysis was done through the implementation of seven steps in the SSM approach. The seven steps are:

1. Situational analysis of the existing problems, in this case, is the institutional problem in the development and utilization of bioenergy of palm oil to meet the electricity needs of rural communities. The important question that needs to be answered in this early stage is how the real situation is related to inter-institutional relationships from various parties ranging from a strategic level to an operational technical level.
2. Knowing what problems exist on various stakeholders seen from the needs, constraints, objectives, and roles of activities and responsibilities respectively.

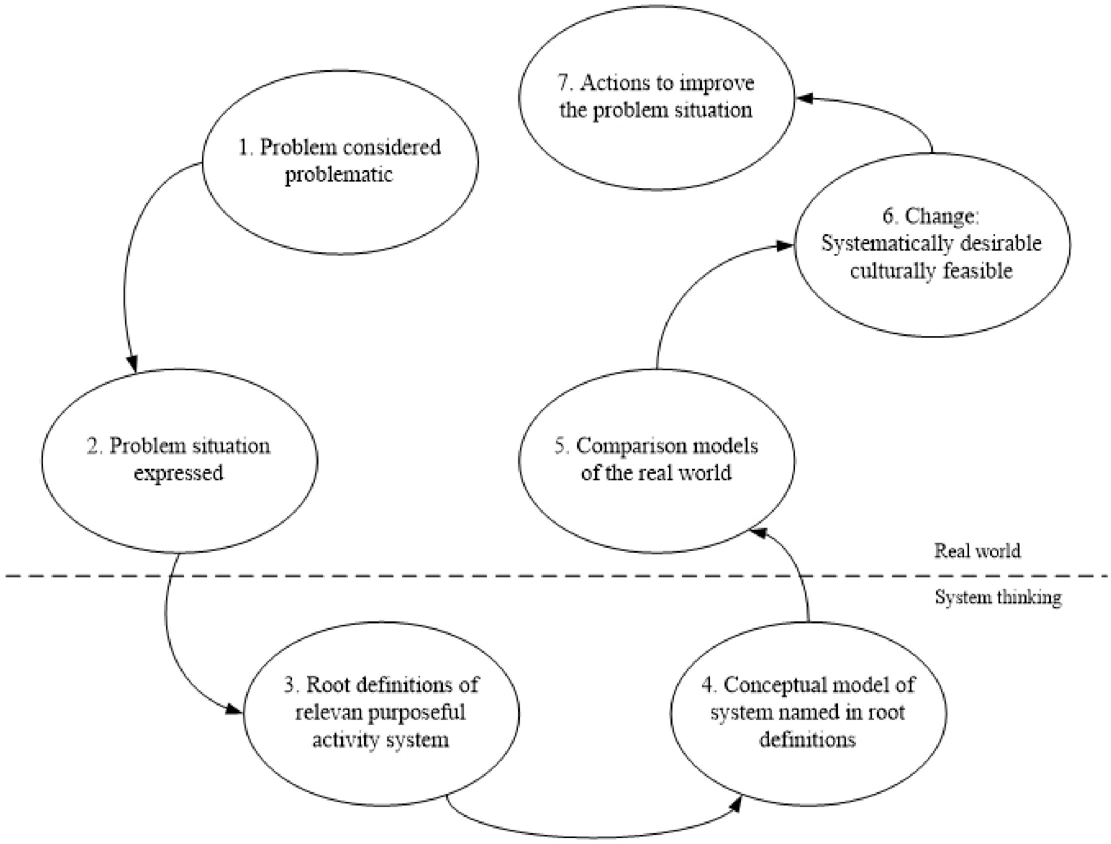

Fig. 1 SSM diagram

The output of this stage is a Rich Picture, which illustrates the relationship between one actor with another actor.

3. Define the function of each party into an approach called CATWOE (Client or Customers, Actors, Transformations, Weltanschauung, Owner, and Environment Constraint).
4. Designing a conceptual model that explains the relationship between activities with other activities. The conceptual model describes the input-process-output relationship between one activity and another.
5. Prepare the agenda of activities that will be done in the real field and at the same time to make a comparison between the real world with the conceptual model that has been designed previously.
6. Define possible changes to be implemented. Some changes that may occur include changes in procedures, changes in structure or changes in attitude and culture in the form of changes in values, norms or ways of thinking.
7. Applying corrective action especially to the model that has been built.

For more structured and measurable decision-making purposes, SSMs should be supplemented by quantitative systemic methodology and numerical databases. This methodology is known as Hard System Methodology (HSM). HSM is a methodology that utilizes various numerical techniques and operational research through the application of critical system thinking. The main stages of HSM include:

1. the formulation of the subject and the problem;
2. construct a mathematical model that represents the system under study;
3. establish solutions to the issues of study;
4. testing of the models and solutions obtained;
5. take control of solutions;
6. application of solutions (Eriyatno, 2013).

3 Methodology

3.1 Research design

Generally, this study consists of the following steps:

1. analysis of existing conditions;
2. identification of research problems;
3. data collection; and
4. analysis of data obtained and reporting.

Existing condition analysis is done through literature review to various related studies that come from various previous research or activity reports obtained from various related institutions. Some of the aspects studied in this stage are related to the potential, development, utilization and regulations and policies related to bioenergy in Indonesia.

Identification of problems is needed to obtain information related to the needs and problems of each stakeholder in realizing the development and utilization program of bioenergy of palm oil to meet the electricity needs of rural communities. Problem identification was conducted through brainstorming, discussion, and interview directly with the experts. Data were obtained through the distribution of questionnaires arranged in such a way as to meet the needs of the analysis. The analysis was performed using HSM techniques to obtain more measurable and structured analysis results. The whole stages become the main parts of the seven stages in the SSM methodology. The framework of research thinking is presented in Fig. 2.

3.2 Data collection method

In this research, data have been obtained using several methods, such as discussion or interview with the respondent. To obtain a more measurable response, an opinion trail was done through the questionnaire distribution. The study involved 12 respondents who are experts with more than 15 years' experience in their respective fields. Experts come from different fields and institutions, including:

1. the central government, in this case from the Directorate General of Renewable Energy and Energy Conservation (DGREEC), the Indonesian Ministry of Energy and Mineral Resources (MEMR);
2. local government, in this case, represented by the Office of Mining Energy and the Office of Agriculture of Horticulture and Plantations;
3. associations and researchers in the field of palm oil and renewable energy;
4. practitioners in companies engaged in oil palm plantations and processing, energy development companies and State Electricity Companies (SEC); and
5. the researchers at the university.

The distribution of the number of respondents by institution and group of expertise areas can be seen in Table 1.

3.3 Analysis method

3.3.1 Interpretive Structural Modeling (ISM)

Interpretive Structural Modeling (ISM) is a group assessment process which produced structural models to describe the complex subject of a system, through a carefully designed pattern to use graphics and sentences (Eriyatno, 2013). ISM is a methodology for identifying relationships between specific items, which define a problem or an issue (Attri et al., 2013).

The ISM technique has been used by researchers in various fields. Talib et al. (2011) have used ISM techniques

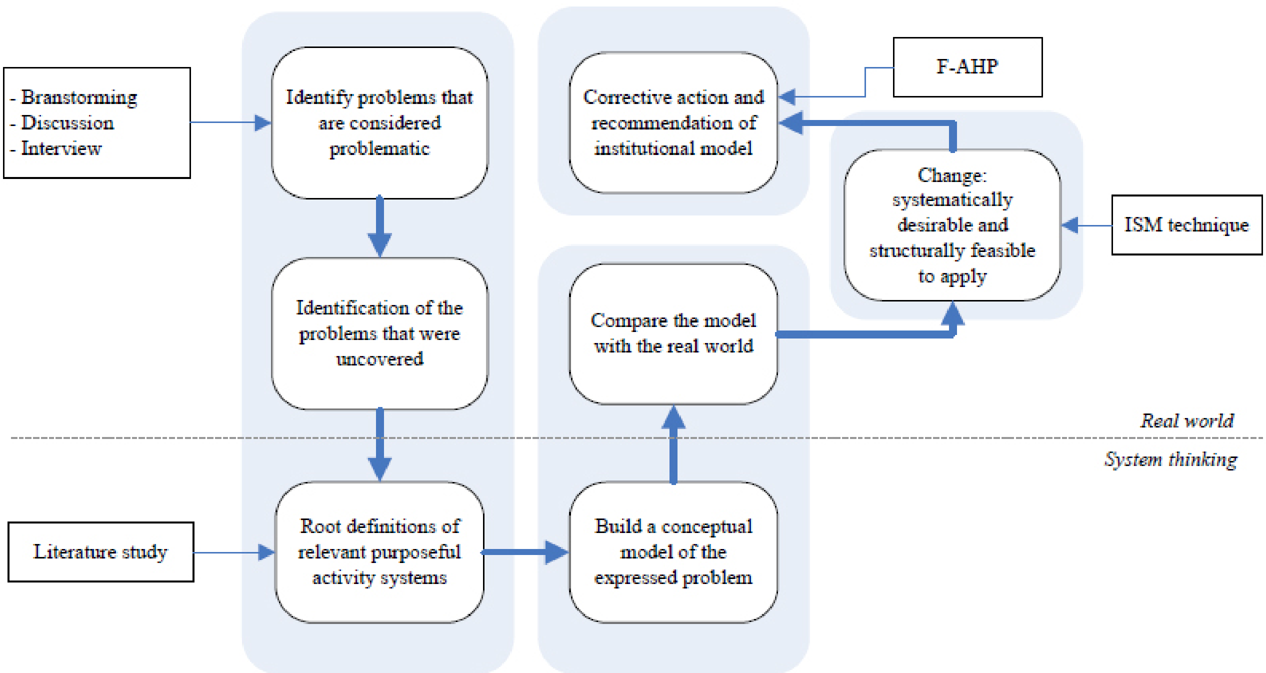

Fig. 2 Diagram of research methodology

Table 1 The respondent based on institution and area of expertise

	Institutions	Position / Expertise Field	Expert number
1.	Ministry of Energy and Mineral Resources	Head of the bioenergy program preparation	1
2.	Mining and Energy Office of the Riau Province	Inspectorate of electricity	1
3.	Department of crops, horticulture and plantation of Riau Province	Head of Technical Services Unit (UPT) testing and implementation of plantation technology	1
4.	PT Perkebunan Nusantara (PTPN) – V	Head of planning and program	1
5.	Energy Development Company	Head of technical and operational areas	1
6.	State power company of Riau and Riau Islands	Deputy of planning manager	1
7.	Association of palm oil	Indonesian palm oil community	1
8.	Association of energy	Renewable energy and social community	2
9.	University	Researchers and academician	3

in analyzing the interaction between barriers for the application of total quality management. In relation to risk issues in the supply chain, Pfohl et al. (2011) have used ISM techniques to structure supply chain risks. Similarly, Udayana et al. (2010) also use ISM techniques in structuralizing supply chain issues especially in palm oil-based biodiesel agroindustry. Associated with institutional studies, Lolowang (2012) has successfully identified many critical success factors of institutional development such as goals, actors, constraints, development activities and success indicators on the development of sugar palm industry cluster. Meanwhile, Dharmayanti (2015) managed to integrate various groups of stakeholders in an area of development as well as the pattern of cooperative relationships between parties involved, such as government, private and state enterprises into an institutional model shaped cluster of the palm oil industry. Wisena et al. (2014) have also used ISM techniques in determining the strategy of increasing competitiveness in the palm oil industry.

ISM is a methodology for the hierarchy building of elements and sub-elements, represented by their drivers-power and dependence, and classified in categories such as autonomous, dependent, linkages, and independent variables (Saxena et al., 1992). In this study, the use of ISM is divided into two stages, namely the preparation of hierarchy and classification of sub-elements described as follows (Eriyatno, 2013; Saxena et al., 1992):

1. Building the hierarchy:

   Preparation of hierarchy on modeling using ISIM, can be applied with the following stages:

   - Hierarchy of problem structures into elements and each element will be decomposed into several sub-elements.
   - Establish contextual relationships between sub-elements that contain a direction in the subordinate terminology leading to paired comparisons (by experts).
   - The contextual relationship is presented in Structural Self-interaction Matrix (SSIM) using the VAXO symbol which is then transformed into binary number matrix (numbers "0" and "1"). The description of ISM-VAXO relationship conditions is described in Table 2. The value $e_{ij} = 1$, explains that there is a contextual relationship between sub-element i and j, while the value $e_{ji} = 0$, explaining that there is no relationship between sub-elements.
   - Transformation of SSIM Matrix into Reachability Matrix

     After the SSIM is formed, a Reachability Matrix (RM) table (see Table 3 to Table 6) is created by replacing V, A, X, and O into numbers 1 and 0. Next it is calculated by the transivity rule by creating a collection of SSIM until a closed matrix is then processed further. Revision of matrix transformation can be done by using computer program. Further processing of the Reachability Matrix table (see Table 3 to Table 6) that has

Table 2 The symbol of contextual relationships and definitions between the ISM-VAXO elements

Inter element symbol i and j (e_{ij})	Definition of contextual relationship between elements (e_{ij})
V	The i element causes a contextual relationship with j but not vice versa ($e_{ij} = 1$ and $e_{ji} = 0$)
A	The j element causes a contextual relationship with the i element, but not vice versa ($e_{ij} = 0$ and $e_{ji} = 1$)
X	The i and j elements cause the contextual connection to each other ($e_{ij} = 1$ and $e_{ji} = 1$)
O	The elements to j and i do not cause contextual relationships to each other ($e_{ij} = 0$ and $e_{ji} = 0$)

Table 3 Reachability Matrix (RM) of program needs

Sub-elements	E1	E2	E3	E4	E5	DP	Rank
E1	1	1	1	0	1	4	1
E2	1	1	1	0	1	4	1
E3	0	0	1	0	0	1	2
E4	0	0	0	1	0	1	2
E5	1	1	1	0	1	4	1
D	3	3	4	1	3		

Table 4 Reachability Matrix (RM) of major constraints

Sub-elements	E1	E2	E3	E4	E5	E6	DP	Rank
E1	1	1	1	0	0	0	3	1
E2	0	1	0	0	0	0	1	2
E3	0	0	1	0	0	0	1	2
E4	0	0	0	1	0	0	1	2
E5	0	0	0	0	1	0	1	2
E6	0	0	0	0	0	1	1	2
D	1	2	2	1	1	1		

Table 5 Reachability Matrix (RM) of program objectives

Sub-elements	E1	E2	E3	E4	E5	E6	E7	DP	Rank
E1	1	0	1	1	1	1	1	6	1
E2	0	1	0	0	0	0	0	1	5
E3	0	0	1	0	0	0	1	2	4
E4	0	0	1	1	1	1	1	5	2
E5	0	0	1	0	1	0	1	3	3
E6	0	0	0	0	0	1	0	1	5
E7	0	0	1	0	0	0	1	2	4
D	1	1	5	2	3	3	5		

Table 6 Reachability Matrix (RM) of supporting factors

Sub-elements	E1	E2	E3	E4	E5	E6	DP	Rank
E1	1	1	0	0	0	0	2	2
E2	0	1	0	0	0	0	1	3
E3	0	0	1	0	0	0	1	3
E4	1	1	0	1	0	0	3	1
E5	0	1	0	0	1	0	2	2
E6	0	1	0	0	1	1	3	1
D	2	5	1	1	2	1		

complied with the transivity rule is the determination of the choice of level (level partition) = 0 is that there is no contextual relationship between the *i* sub the element and the *j*. Based on Reachability Matrix table (see Table 3 to Table 6), the Driver-Power (DP) values can be determined by summing the sub-elements horizontally, where the rank values are determined based on the value of the power-driver sorted from the largest to the smallest, while the dependence (*D*) value is derived from the sum of sub-element values vertical and level values are determined based on the dependence value sorted from the largest to the smallest.

2. Classification of sub-elements

In general, the classification of sub-elements is classified into four sectors (see Fig. 3):

- Sector I: (*weak driver power and weak dependent variables*). Sub-elements included in this sector are generally not associated with the system, or autonomous.
- Sector II: (*weak driver power but strongly dependent* variables). In general, the sub-elements that are included in this sector is a sub-element that is dependent.
- Sector III: (*strong driver power and strongly dependent variables*). Sub-elements entering in this sector should be studied carefully because the relationship between the elements is not stable. Any action on the sub-element will have an impact on the other sub-elements and the effect of its feedback can magnify the impact or linkage.
- Sector IV: (*strong driver power but weak dependent variables*). Sub-elements entering in this sector are the remaining parts of the system and are called independent variables.

3.3.2 Fuzzy Analytical Hierarchy Process (F-AHP)

Analytical Hierarchy Process (AHP) is a method developed by Saaty (2008). The main objective of the AHP analysis is to make an alternative decision ranking and select one of the best for multi-criteria cases combining qualitative and quantitative factors in the overall evaluation of alternatives (Shega et al., 2012).

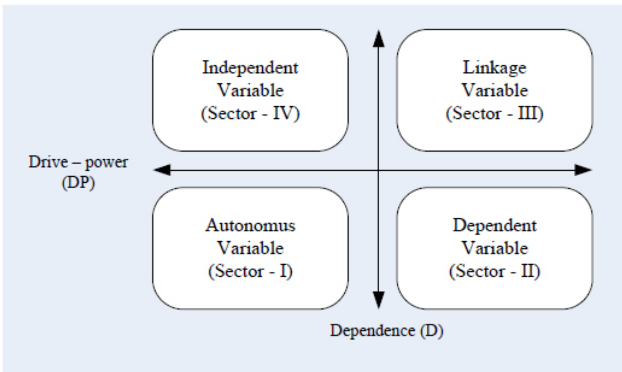

Fig. 3 Drive-power and dependence diagram

Fuzzy Analytical Hierarchy Process (F-AHP) is a combination of the AHP method with a fuzzy concept approach. F-AHP can mask the usual AHP weakness, that is, problems with higher subjective dominance. Uncertainty is represented by a non-singular scale sequence. Chang (1996) developed the F-AHP method by using triangle membership function or Triangular Fuzzy Number (TFN). Chang (1996) defines the value of the intensity of the AHP into a triangular fuzzy scale that divides each fuzzy set by 2, except for the intensity of interest 1. The F-AHP settlement procedures can be applied by the following steps (Marimin et al., 2013):

- Comparison of scores.
  The fuzzy triangular numbers are used to indicate the relative importance level of each element pair in the same hierarchy.
- Formation of fuzzy comparison matrix.
  By using fuzzy numbers through pairwise comparisons, the fuzzy number matrix $\tilde{A}\left(a_{ij}\right)$ is made using the following Eq. (1):

$$\tilde{A}=\begin{bmatrix}1 & \tilde{a}_{12} & \dots & \tilde{a}_{1n}\\ \tilde{a}_{21} & 1 & \dots & a_{2n}\\ \tilde{a}_{m1} & a_{m2} & \dots & 1\end{bmatrix}, \tag{1}$$

  with $\tilde{a}_{ij}^{\alpha}=1$, if $i=j$ and

  $\tilde{a}_{ij}^{\alpha}=\tilde{1},\tilde{3},\tilde{5},\tilde{7},\tilde{9}$ or $\tilde{1}^{-1},\tilde{3}^{-1},\tilde{5}^{-1},\tilde{7}^{-1},\tilde{9}^{-1}$, where $i\neq j$.

- Completion of fuzzy eigenvalues.
  This step aims to calculate the relative importance of all elements based on elements at the upper levels in the hierarchical structure. The fuzzy eigenvalues can be obtained by the Eq. (2):

$$\tilde{A}\tilde{x}=\tilde{\lambda}\tilde{x}. \tag{2}$$

  $\tilde{A}$ represents ($n \times n$) a fuzzy matrix that contains the fuzzy number $\tilde{a}_{ij}$ and $\tilde{x}$ represents ($n \times 1$) the fuzzy vector containing the fuzzy number $\tilde{x}_i$, to perform multiplication and addition using interval and α-cut arithmetic, Eq. (2) is converted to Eq. (3):

$$\left[a_{i1l}^{\alpha}x_{1l}^{\alpha},a_{i1u}^{\alpha}x_{1u}^{\alpha}\right]\oplus\ldots\oplus\left[a_{inl}^{\alpha}x_{nl}^{\alpha},a_{inu}^{\alpha}x_{nu}^{\alpha}\right]=\left[\lambda x_{il}^{\alpha},\lambda x_{iu}^{\alpha}\right] \tag{3}$$

  with

$$\tilde{A}=\left[\tilde{a}_{ij}\right],\ \tilde{x}^{t}=\left(\tilde{x}_1,\ldots,\tilde{x}_n\right) \tag{4}$$

$$\tilde{a}_{ij}^{\alpha}=\left[a_{i1l}^{\alpha},a_{i1u}^{\alpha}\right],\ \tilde{x}_i^{\alpha}=\left[x_{il}^{\alpha},a_{iu}^{\alpha}\right],\ \tilde{\lambda}^{\alpha}=\left[\lambda_{il}^{\alpha},\lambda_{iu}^{\alpha}\right]. \tag{5}$$

  For $0<\alpha<1$ and all i, j, with i = 1, 2, ..., n and j = 1, 2, ..., m. The subscripts "l" and "u" indicate the lower and upper values of the fuzzy set defined in the fuzzy membership function. According to (Marimin et al., 2013), priority setting can be simplified by the Eq. (6):

$$x_i=\frac{\sum_{i=1}^{n}\left(\frac{a_{ij}}{\sum_{j=1}^{n}a_{ij}}\right)}{n}. \tag{6}$$

  The value of α cut is the level of confidence of the expert or the decision maker of his judgment. The degree of satisfaction of the assessment of $\tilde{A}$ matrix is estimated by the index of optimism ω. The greater the value of ω then shows, the more optimistic the decision maker. This index is a combination of linear convex which can be defined by the Eq. (7):

$$\tilde{a}_{ij}^{\alpha}=a_{iju}^{\alpha}+(1-\omega)a_{ijl}^{\alpha},\ \forall\omega\in[0,1]. \tag{7}$$

  If the value of α is fixed, the following matrix (Eq. 8) can be obtained after setting the optimism index ω to estimate the satisfaction level:

$$\tilde{A}=\begin{bmatrix}1 & \tilde{a}_{12}^{\alpha} & \dots & \tilde{a}_{1n}^{\alpha}\\ \tilde{a}_{21}^{\alpha} & 1 & \dots & \tilde{a}_{2n}^{\alpha}\\ \tilde{a}_{n1}^{\alpha} & \tilde{a}_{n2}^{\alpha} & \dots & 1\end{bmatrix}. \tag{8}$$

Normalization in pairwise comparisons and the calculation of priority weights is performed by the calculation of eigenvectors. To control the results of this method, we calculate the Consistency Ratio for each matrix and the entire hierarchy. The Consistency Index is measured using the Eq. (9):

$$\mathrm{CI}=\frac{\lambda_{maks}-n}{n-1}, \tag{9}$$

with CI as the Consistency Index, λ_{mals} is a consistency vector and n is the number of alternatives. Meanwhile, the Consistency Ratio (CR) can be calculated by the Eq. (10):

$$\mathrm{CR}=\frac{\mathrm{CI}}{\mathrm{RI}}, \tag{10}$$

where CR is a Consistency Ratio and RI is a Randomly Generated Average Index. The function of fuzzy membership used is Triangular Fuzzy Number (TFN). TFN membership function is formulated as presented in Table 7.

The upper and lower limits of the fuzzy number are then set based on the α-cut value using Eqs. (11) to (15):

$$\tilde{1}_{\alpha}=[1,3-2\alpha] \tag{11}$$

Table 7 TFN membership function

Fuzzy Number	Explanation of importance between variables	TFN Membership Function	TFN reciprocal
~1	*A* equally important with *B*	1,1,3	(1/3, 1, 1)
~3	*A* is slightly more important than *B*	1,3,5	(1/5,1/3, 1)
~5	*A* is clearly more important than *B*	3,5,7	(1/7, 1/5, 1/3)
~7	*A* very obviously more important than *B*	5,7,9	(1/9, 1/7, 1/5)
~9	*A* is absolutely more important than *B*	7,9,9	(1/9, 1/9, 1/7)

$$\tilde{3}_\alpha = [1+2\alpha, 5-2\alpha],\ \tilde{3}_\alpha^{-1} = \left[\frac{1}{5-2\alpha}, \frac{1}{1+2\alpha}\right] \quad (12)$$

$$\tilde{5}_\alpha = [3+2\alpha, 7-2\alpha],\ \tilde{5}_\alpha^{-1} = \left[\frac{1}{7-2\alpha}, \frac{1}{3+2\alpha}\right] \quad (13)$$

$$\tilde{7}_\alpha = [5+2\alpha, 9-2\alpha],\ \tilde{7}_\alpha^{-1} = \left[\frac{1}{9-2\alpha}, \frac{1}{5+2\alpha}\right] \quad (14)$$

$$\tilde{9}_\alpha = [7+2\alpha, 11-2\alpha],\ \tilde{9}_\alpha^{-1} = \left[\frac{1}{11-2\alpha}, \frac{1}{7+2\alpha}\right]. \quad (15)$$

The AHP is a model that describes the relationship of variables related to activity in the bioenergy field, either from activities along the value chain (criteria), which refers to the elements of needs, constraints, actors (stakeholders) as well as the supporting factors of development and utilization palm oil-based bioenergy to the provision of electricity for rural communities. The AHP structure modeling is based on the results of previous research, respondents with experts, and through approaches to prioritize bioenergy development based on the potential of oil palm plantations and the economic, social and environmental conditions in the Riau Province. The criteria, stakeholders and alternative institutional models, are summarized in Table 8.

4 Results

4.1 SSM to identification institutional issue

To identify the problem of the program, a series of interviewing activities has been conducted to various stakeholders, both from government and industry practitioners. Some government institutions that have relevance to the existing problems, among others the Ministry of Energy and Mineral Resources, the Department of Mining and Energy at the local level, the Ministry of Agriculture, the Department of Plantations at the local level, the Ministry of Environment and the Environment Agency at the regional level. Interviews were also conducted with related companies primarily engaged in oil palm plantation and processing, energy development companies and SEC. Besides, document review has also been made on various existing policies, whether in energy, environment or agriculture.

The results of discussions and interviews with related parties are an input to identify the institutional issues in the development and utilization of bioenergy of palm oil to meet the electricity needs of rural communities. Problem identification until the recommendation of problem-solving action is an important part of each SSM step.

4.1.1 Stage - 1: Situation considered problematic

In Indonesia, the use of palm oil as a source of energy raw materials, especially for electricity supply for the community tends to be very low. On the other hand, in some areas especially rural areas there are still many who have not received an electricity supply due to distance factors too difficult to reach by the state-owned power grid. Various obstacles ranging from policy, institutional and technical and operational lead to the realization of bioenergy development of palm oil to meet the electricity needs for the community still has not done well.

Various issues related to the policy, among others, relate to the status of waste from the aspect of energy

Table 8 Criteria, stakeholders and alternatives of the institutional model

	Criteria	Symbol	Stakeholders	Symbol	Alternatives	Symbol
1.	Availability of investment capital	C1	Ministry of Energy and Mineral Resources	S1	Convert one of the state / regional palm oil companies	A1
2.	Ability to supply raw materials	C2	Provincial / local government	S2	Establishment of specialized and new energy development companies	A2
3.	The ability of human resources in the use of technology	C3	Oil palm plantation companies	S3	Establishment of a consortium between government, private and SEC	A3
4.	Availability of adequate land	C4	Palm oil agro-industry company	S4	Partnerships between state / local palm oil companies and energy development companies, with BOOT systems	A4
5.	Support of various stakeholders	C5	Energy development company	S5		
6.			State Electricity Company	S6		

sources and environmental sustainability. Currently, palm oil waste is the potential to be utilized as an energy source, but because it is still in the form of waste that has the potential to harm the environment, causing a contradictory relationship between the two conditions. Therefore, it becomes very important to establish the current status of palm oil waste if it will be used as an energy source.

On the other hand, the development of biogas power plants by utilizing palm oil liquid waste requires a huge investment and the availability of technology and human resources that have the capability in operating the power plant. Oil palm plantation or processing companies have limitations to be able to carry out energy development or operate the power plant. Therefore, it needs support and cooperation from other parties who have the capability in terms of capital, technology, and human resources.

So far, the cooperation is still limited only to meet the internal electricity needs for the palm oil company, especially in supporting the production process at the palm oil mill. Through cooperation with the lease system within a certain time, oil palm plantation and processing companies are obliged to purchase electricity that has been produced by energy development companies. Generally, cooperation contracts are made in the form of BOT (built operate transfer), where the construction and operation of power plants is done by energy development companies, then within the period of asset ownership handed over to oil palm plantation and processing companies.

In terms of commercialization, some policies still have not given a positive response, so it becomes an obstacle for both the supply of electricity, in this case the plantation companies and energy developers, as well as for SEC which is given the authority in distributing and marketing electricity to customers. In the Minister of Energy and Mineral Resources (MEMR) Regulation Number 50 Year 2017 (Ministry of Energy and Mineral Resources, 2017b), raises an understanding that the commercialization of electricity to SEC resulted in the ownership of power plant assets belong to SEC. This is certainly an obstacle for both parties, both for plantation companies and for SEC itself, thus causing the continuity of electricity supply to be disrupted. Meanwhile, for the sale of biomass-based electricity to the public is the authority of SEC following the Minister of Energy and Mineral Resources (MEMR) Regulation Number 27 Year 2014 (Ministry of Energy and Mineral Resources, 2014). As a result plantation companies or energy developers cannot carry out electricity sales directly to the community. This has led to various problems still hampering the efforts of governments and other stakeholders to meet the power needs of rural communities.

4.1.2 Stage – 2: Problem situation expressed.

Based on situational analysis taking into account the conditions and roles of various stakeholders, among others from the government, oil palm plantation and processing companies, energy development companies and SEC, it can express various problems as follows:

- On the ISPO certification standard (Indonesian Sustainable Palm Oil), in the Regulation of the Minister of Agriculture Number 11 Year 2015 has stated that the development of new renewable energy or bioenergy on oil palm plantations is still voluntary (Ministry of Agriculture, 2015). At present, not many plantation companies and palm oil mills are able or willing to undertake bioenergy development by utilizing palm oil waste for several reasons:
  1. no regulation requires companies to develop energy through the use of palm oil waste;
  2. bioenergy development of palm oil will require investment, additional costs and resources. Economically, some palm oil companies consider that bioenergy development has not benefited them;
  3. administrative and bureaucratic issues mainly related to licensing which is considered quite difficult;
  4. low energy market prospect, especially for palm oil company which is far from the residential area;
  5. the problem of technological capability is still limited.

- Related to the unclear status of palm oil waste (empty bunches, shell, fiber, liquid waste) whether as waste or energy. If as waste, of course the factory must have a waste utilization permit. Conversely, if as energy, does the permit owned by the palm oil factory include the license for the utilization and sale of biogas and biomass (shell). In addition, if it is designated as an energy source, in accordance with Law Number 30 Year 2009 on energy, that new and renewable energy resources are regulated by the state and utilized as much as possible for the welfare of the people (clausal 4) (Indonesia Republic of Government, 2009). In addition, in clause 6 and paragraph 3 it is also affirmed that the utilization of energy sources is prioritized for the interests of the national electricity.

- Status of palm oil mill waste viewed from the perspective of environmental sustainability. Utilization of waste as a source of energy raw materials, until now is still a debate among various stakeholders. On the one hand, waste management to meet energy needs is very important in supporting the economy and social needs for the community, but on the other hand, waste management that is not by the provisions can harm environmental sustainability. Therefore, efforts to utilize waste as an energy source need to get permission from the government, especially the ministry or environmental agency. This is done to avoid mistakes both in terms of management, as well as in terms of utilization so that negative impacts that may occur can be minimized as small as possible.
- The development of biogas power plant is generally done through the application of methane capture technology to the palm oil mill effluent installation. The installation of liquid waste disposal is one of the important parts and becomes one unit of the palm oil manufacturing process. Due to the limited capital and technological capabilities of oil palm plantations and processing companies, for the development of PLTBG can be done by others who are companies engaged in energy development. The cooperation contract system can be done in the form of BOT (Built Operate Transfer) or BOO (Built Operate Owner) with a certain period in accordance with the agreement of both parties. There is a doubt that the commercialization of electricity causes ownership of assets to move to SEC (MEMR Regulation Number 50 of 2017) (Ministry of Energy and Mineral Resources, 2017b). This can lead to problems for plantation companies, because the construction of power plants is generally carried out on the installation of liquid waste disposal of palm oil mills. If ownership to SEC will cause the production process and waste disposal from the palm oil, the mill will be covered. On the other hand, the transfer of assets to SEC causes SEC's dependence on plantation companies, since the supply of waste to be the main resource for producing electricity can only be produced by palm oil mills.
- Commercialization of electricity to the community requires no small investment for the government or SEC. Economically, there needs to be a balance between the investment cost and the rate of return on the purchase of electricity by the community.
- Direct sales of electricity to communities cannot be done by plantation companies or energy developers. It is regulated in MEMR Regulation Number 27 of 2014, that the commercialization of electricity to the public is the authority of the government, where the mechanism of sale is handed over to SEC (Ministry of Energy and Mineral Resources, 2014).

The mapping of existing problems based on their relationship of condition and role has been done using the Rich Picture Diagram (see Fig. 4). The rich picture will further clarify the description of the problem along the supply chain, both in terms of policy issues, cross-cutting relationships or from the technical side.

4.1.3 Stage – 3: Root definition of relevant system

This stage seeks to translate the reality of existing problems into a model framework. This section outlines the various interest groups that have a role in the development of bioenergy of palm oil to meet the needs of the rural community electricity. Each party is grouped according to the roles and needs of each, both as actors who perform the transformation process and also the provider of benefits, or customer as beneficiaries. The CATWOE method (customers, actors, transformation, weltanschauung, owner and environment constraint) is used to define related parties, the role of each party and various constraints that may be faced in the effort to achieve the objectives of the problem. The root definition of the problems are presented in Table 9.

Client or *customer*, in the definition of the institutional system elements of this bioenergy palm oil supply chain, is a rural community that has not received electricity from SEC. Generally, they are in remote areas too difficult to reach the electricity network SEC. The main need for this group is the availability of electricity all the time, with good quality and a reasonable price.

Actors are the parties that have a strategic role in generating various benefits for the community, through the transformation of various entities in accordance with their respective fields. The government is the actor who plays the biggest role in setting rules and policies. The policy is designed to create harmonization and maintain a balance between various aspects of interests, whether those interests are related to economic, social and environmental issues. The government also has a commitment to the electricity supply program as a form of responsibility to the community as a whole. In addition, government efforts need to get support from the industry, including oil

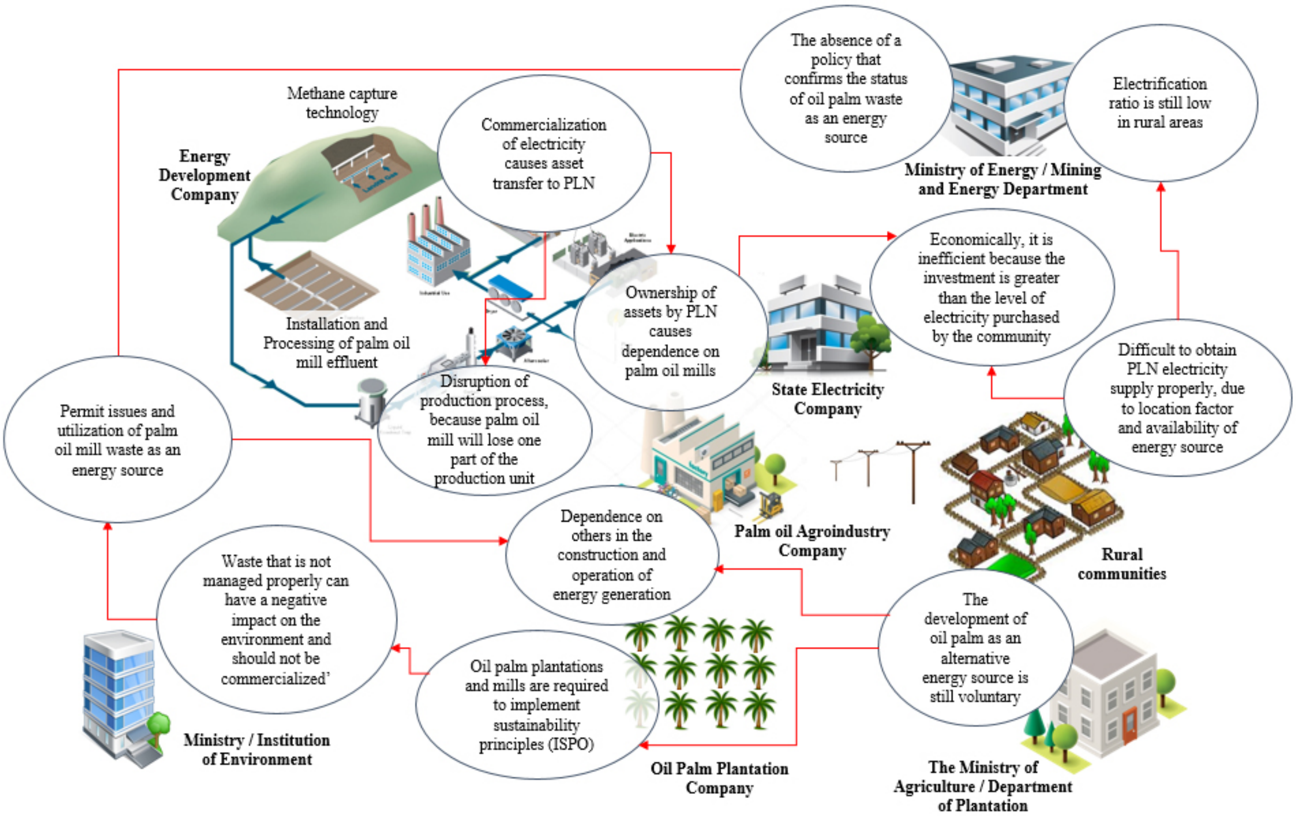

Fig. 4 Rich picture of the institutional problem

Table 9 Root definition of the problems

Components		System definition of each component
C	Customer / Clients	Rural communities (located in remote and isolated from the grid) as beneficiary
A	Actors	Government, oil palm plantation and palm oil agro-industry companies, energy development company, SEC
T	Transformation Process	The transformation of resources (biomass) from plantations and palm oil mills into electrical energy; role transformation in accordance with established rules and policies
W	Weltanschauung	The realization of policies and regulations that provide alignments to all stakeholders
O	Owner	Central and local government (Ministry of Energy and Mineral Resources, Ministry of Environment, Ministry of Agriculture and Plantation)
E	Environment Constraint	Interpretations and perceptions of various stakeholders in the context of existing relationships, roles and policies, particularly related to the status of waste as energy resources, which have economic value and impact on the environment

palm plantation and processing companies that play a role in the provision of energy raw materials, energy development companies that play a role in transforming the waste of palm oil into electricity and SEC as an institution authorized to distribute and marketing electricity to the public.

Transformation process, activities and roles that need to be implemented by various stakeholders in the effort to reach the target, that is, fulfillment of the electric energy requirement for rural society. Each side has different transformation roles but influences each other. The government has a role in creating policies and regulations that serve as guidelines for other stakeholders. On the other hand, oil palm plantation and processing companies have an important role in the provision of raw materials in the form of waste and biomass as energy sources, while energy developers have a role in transforming waste into electrical energy. Furthermore, the purchase of electricity from the company, distribution and marketing to the community is the responsibility of SEC.

Weltanschauung (worldview), derived from the German language that suggests meaningful insight or understanding must-have that makes the various definitions become meaningful in accordance with the context. The problems in this study are essentially due to the absence of an agreement that is able to balance between the objectives, the obstacles of the various views. Therefore, there is a need for communication and agreement supported by a common commitment among actors, both government and companies.

The owner, in this case, is a government consisting of related ministries as well as ministries in the field of energy, the Ministry of Agriculture and the Ministry of the Environment. In Sub-subsection 4.1.3, the government becomes a key factor in controlling the success of problem-solving. Meanwhile the *environment constraint* are aspects that potentially hamper the implementation of programs and activities to be undertaken by various parties, one of which is related to the different views of the status of palm oil waste as a source of raw materials of energy, waste as a product of commercialization or waste that negatively impacted to the environment, sustainable energy development, continuity of energy supply or related to asset ownership.

4.1.4 Stage – 4: Building conceptual model

The conceptual model describes the relationship between the activities and the roles of each party to achieve their respective targets as well as the basis in the effort to solve the main problem, namely the provision of an electricity supply for rural communities through the development and utilization of bioenergy of palm oil. Each role has a complementary relationship and, sometimes because of the limitations, and the high level of need, will be the source of the problem that must be solved. The conceptual model picture in this study, presented in Fig. 5.

4.1.5 Stage – 5: Comparison models of the real world

In this study, the comparison between model and existing reality is done through an analytical approach using the ISM technique and expert judgment. The use of ISM Techniques aims to restructure the problems to get the key elements that become program priorities.

Structuring the problems with ISM techniques

To further clarify existing problems, it is necessary to do the grouping of problems into elements and sub-elements. Furthermore, with the use of ISM Techniques, the problem of structure is based on the level of influence of each element to the main problems. Technically, the determination of the key element is determined based on the drive-power and dependence value. Each sub-element is ranked based on the drive-power value, where the drive-power value determines the position of each sub-element in the decryption hierarchy (Saxena et al., 1992). The highest drive-power value is a key sub-element and a priority in problem solving.

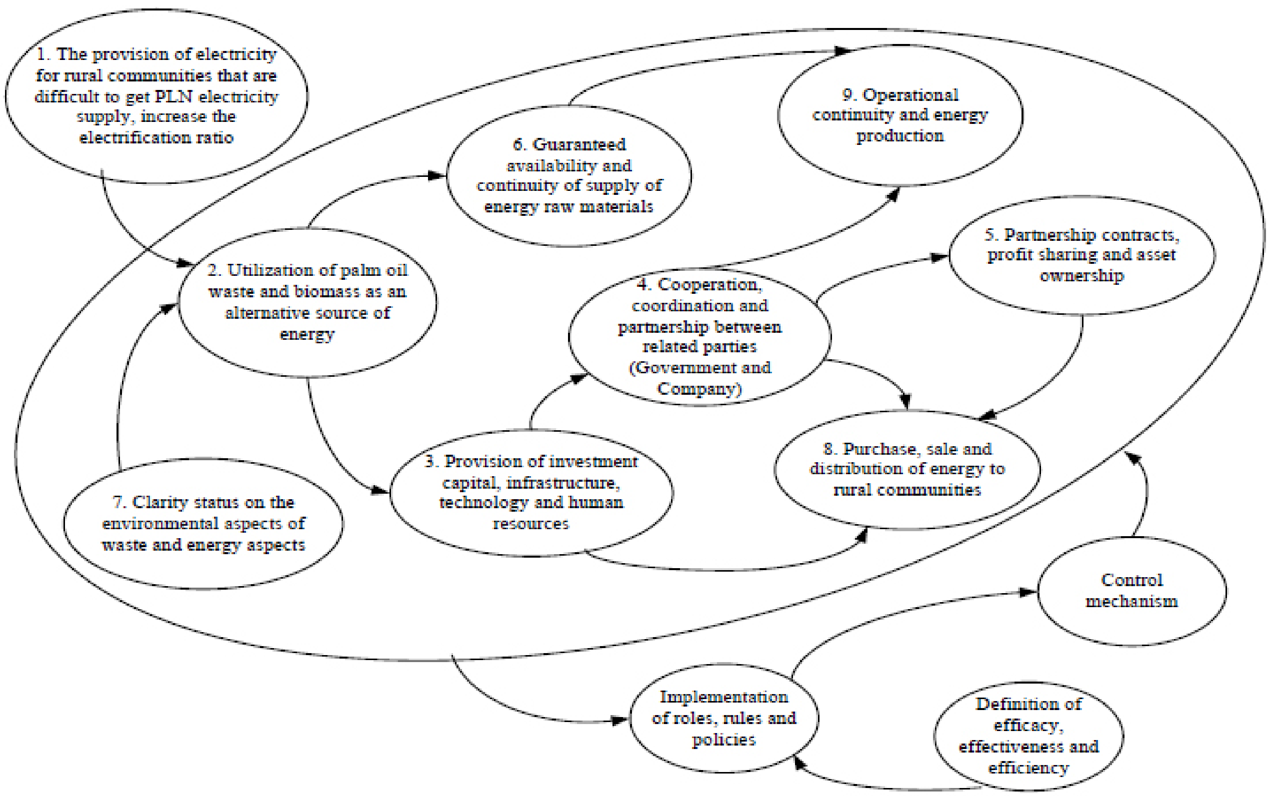

Fig. 5 Institutional conceptual model

In this study, sub-elements are grouped into four main elements consisting of program need elements, major constraint elements, a program objective element and a supporting factor element. The result of the analysis by using the ISM technique for each element will be described:

1. The program needs element
   Elements of need is an element that explains the fundamental need for the implementation of bioenergy palm oil development and utilization program to meet the electricity needs for rural communities. Based on the analysis of the system through expert judgment, 5 sub-elements have been identified, namely:
   1. availability of human resources and technology;
   2. availability of investment capital;
   3. availability of infrastructure and power plant network;
   4. adequate land availability, and
   5. support from various stakeholders. Expert assessment results have been grouped into SSIM matrices and transmitted into the Reachability Matrix as presented in Table 3.

   Based on the results of the transitivity matrix SSIM to Matrix Reachability form, it has obtained the value of drive-power and dependence of each sub-element or requirement element. The three key sub-elements of the needs element include the availability of human and technological resources, the availability of investment capital and the support of the participation of various related institutions. The structure of the program needs is presented in Fig. 6.
2. Major constraints element
   Element constraints are elements that explain factors that may hinder the program's implementation. The sub-elements in the constraints element include:
   1. large investment capital to build power plants;
   2. low return on investment in rural areas;
   3. low investor interest if palm oil mill production is less than 30 tons FFB/day;
   4. there is a debate over the status of waste as a raw material of energy and its impact on the environment;
   5. there is a debate on asset ownership status if the commercialization of electricity to the public (MEMR Regulation Number 50 of 2017) (Ministry of Energy and Mineral Resources, 2017b); and
   6. a lack of integration and harmonization of the role of the relevant institutions.

   The result of the expert opinion that has been transformed into the Reachability Matrix is presented in Table 4. Based on the analysis of the major constraint element, from six sub-elements there is one key sub-element to be the main obstacle, which is the high value of an investment that must be provided to run the program, especially the investment of power plant development based biomass or biogas. To build a biogas-based power plant with a capacity of 1 MW, it is estimated to require an investment cost of IDR 35 Billion.
   In the hierarchy, the structural model of inter-relationship between the sub-elements on the major constraint element can be described as shown in Fig. 7.

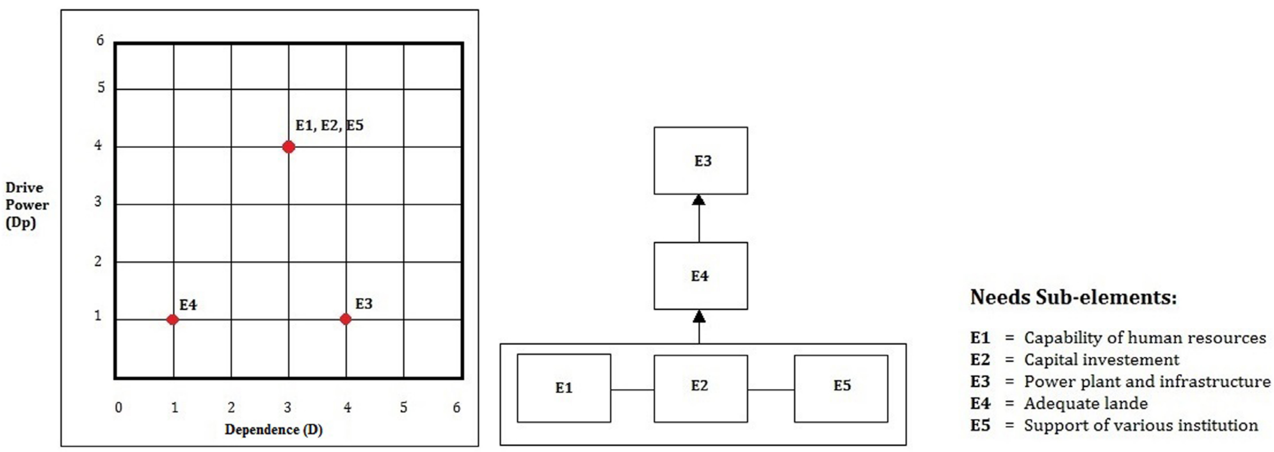

Fig. 6 Diagram of drive power-dependence and structure of program needs element

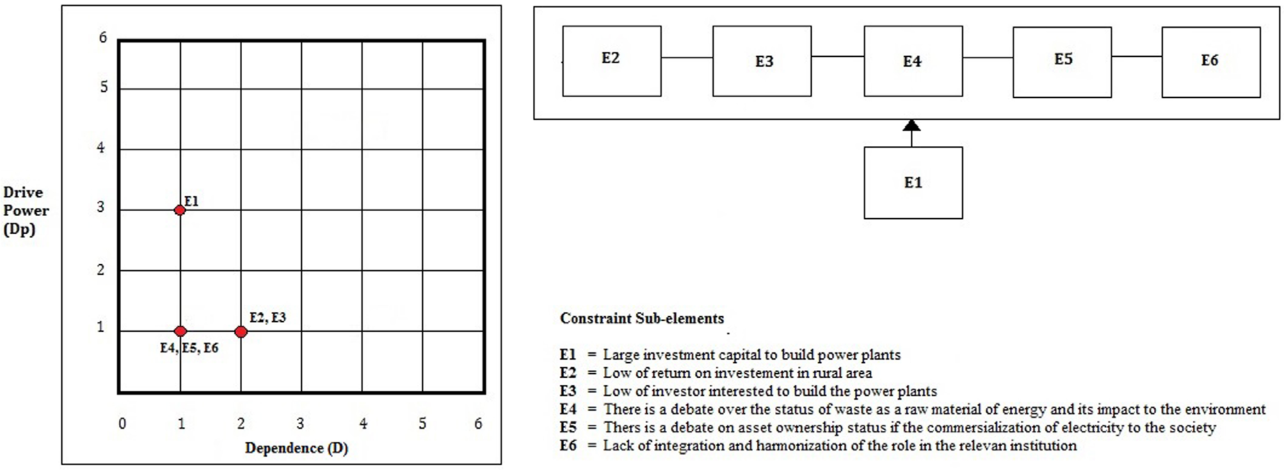

Fig. 7 Diagram of drive power-dependence and structure of major constraints element

3. The program objectives element

   Based on the discussion and assessment of experts, 7 sub-elements have been identified in the program objectives, including:
   1. improving the sustainability of bioenergy development in Indonesia;
   2. improving the effectiveness of the financial sector that supports national development efforts;
   3. increasing the electrification ratio of the community;
   4. Increase the bioenergy contribution in the national energy mix;
   5. realizing national energy security;
   6. Decreasing and preventing environmental impacts, and
   7. improving the social welfare.

   The ISM analysis shows that, of the 7 sub-elements in the objective element, the key sub-elements that need to be a major concern in the implementation of the program is to improve the sustainability of bioenergy development in Indonesia. Expert judgment results that have been transformed into the Reachability Matrix, can be seen in Table 5.

   In the hierarchy, one of the main sub-elements to be the goal of program implementation is to improve the sustainability status of bioenergy development in Indonesia. The structure of program objectives, presented in Fig. 8.

4. The supporting factors element

   The realization of this program is inseparable from the support of various stakeholders, including governments, companies, and communities. Based on the identification and assessment of experts, there are at least 6 sub-elements that can support the implementation of this program, among others:
   1. the availability of special budget and incentives in the state budget and expenditure for the efforts of developing renewable energy;

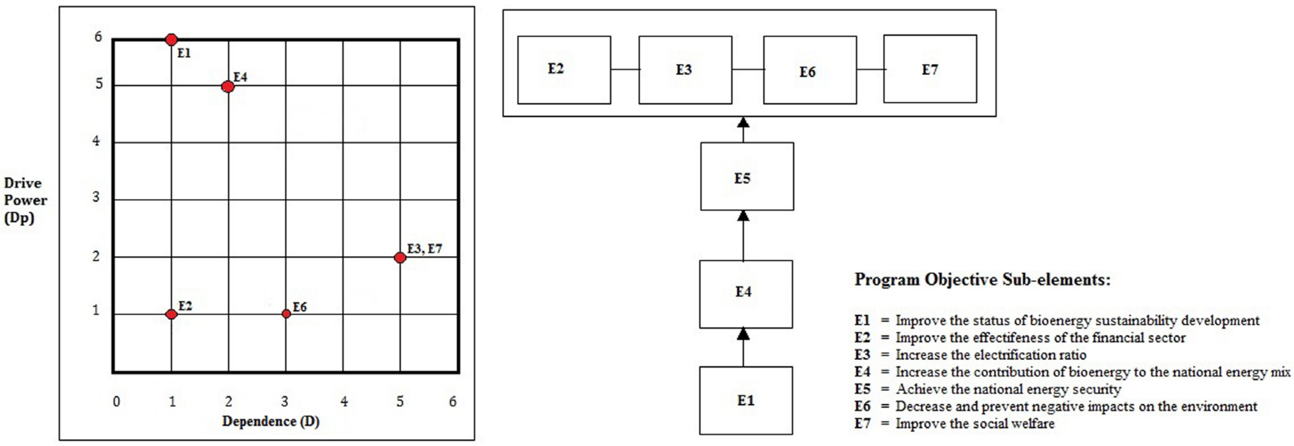

Fig. 8 Diagram of drive power-dependence and structure of program objectives element

2. the energy supply that can be produced is high enough;
3. the experience of the success of various companies in the development and utilization of bioenergy of palm oil;
4. the number of palm oil mills is evenly distributed in each district;
5. there is a chance of various parties in the development of bioenergy (MEMR Regulation Number 39 of 2017) (Ministry of Energy and Mineral Resources, 2017a), and
6. ensuring continuity of supply of raw materials for energy purposes.

The results of the expert assessment of the sub-elements contributing factor have been transformed into the Reachability Matrix, as presented in Table 6.

The ISM analysis shows that more experts perceive that 2 key sub-elements that can support the realization of the program are:

1. the number of palm oil factories spread evenly in each district area; and
2. guarantee of supply of raw materials for energy purposes.

These sub-elements look more measurable and predictable than other sub-elements of support. In a hierarchy, sub-elements in the supporting factor elements can be seen in Fig. 9.

Based on the results of expert assessment analysis using the ISM Technique, key sub-elements of the four main elements in the development and utilization program of bioenergy of palm oil to meet the electricity needs of rural communities. Overall key elements and sub-elements, summarized in Table 10.

4.1.6 Stage – 6: Definition of feasible desirable changes

The development of a palm oil-based power plant is expected to be one solution for efforts to meet the electricity needs of rural communities. This effort requires the attention of various stakeholders, including central and local governments, oil palm plantation and processing companies, companies engaged in energy development or national power companies. Therefore, systematic and structured planning is required, starting from the determination of related policies, the provision of energy raw materials, the construction and management of power plants, to the distribution of electricity to rural communities.

In the previous stages, various problems have been identified that need to get attention and concrete solutions

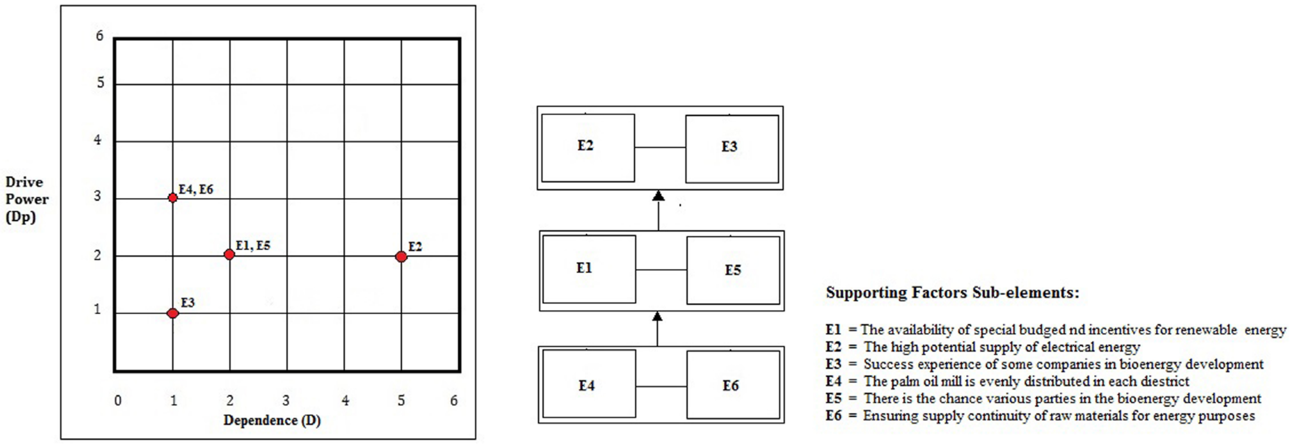

Fig. 9 Diagram of drive power-dependence and structure of supporting factors element

Table 10 Key elements and sub-elements

Elements		Sub-elements
	1.	Capability of human resources in the use of technology
Needs of program	2.	Availability of investment capital.
	3.	Support of various stakeholders.
Major constraints	4.	Large investment capital to build the plant.
Program objectives	5.	Improved status of bioenergy sustainability development in Indonesia.
Supporting factors	6.	The number of palm oil mills is evenly distributed in each district.
	7.	Ensuring continuity of supply of raw materials for energy purposes.

for the realization of the expected goals. Hierarchically, from Table 11 can be described changes are possible.

4.1.7 Stage – 7: Action to solve the problem situation

As the final step in the implementation of SSM, a series of activities is recommended as an alternative solution in answering the existing problem. Resolving the review issues will be more effective if implemented gradually, ranging from the strategic level to the operational level. Solving the existing problems requires a mutually supportive role of each stakeholder consisting of government, enterprises, and society. At this stage, institutional modeling is necessary to ensure the appropriate form of the institution in carrying out its functions, such as the provision of raw materials as a source of energy, the building of power plants, and the conversion of biomass into electrical energy to the distribution of electricity to rural communities.

In the previous stages, possible actions have been identified that can be applied in anticipating the issues studied. In an integrated manner, the action plan to solve the program problems can be described as shown in Fig. 10.

Table 11 The feasible desirable changes

Level	Problematic	Feasible and desirable changes
(Strategic) Policies and regulations	Lack of coordination and cooperation between related government institutions in the formulation of renewable energy policies	Co-ordination between relevant government authorities, in reviewing and formulating various rules and policies. Some of them are Ministry of Energy, Ministry of Agriculture and Ministry of Environment.
	The concerns of oil palm plantation companies against the policy, which states that there will be transfer of asset ownership to SEC in case of commercialization of electricity to the public	Conduct a review and revision of the policies and rules that already exist, such as asset ownership policy and commercialization of electricity and waste state policy in the context of environmental sustainability.
	Unclear status of palm oil waste in energy, economic and environmental context.	Prepare and establish policies, including policies regarding the status and rules of waste utilization as a source of energy. Develop and establish policies related to the commercialization of waste and certification of its management, whether for energy use or for economic purposes and asset ownership.
	Concerns energy development company to sanctions from palm oil waste utilization for energy purposes if the negative impact on environment	Establish standards and classification of waste seen from parameters and thresholds that can be used as a reference to meet energy and environmental interests. Some environmental parameters that need to be set include oxygen or COD (chemical oxygen demand) and acid content.
(Tactical) Development, management and operation	Partnership is still limited between plantation companies and energy development companies with BOT systems and has not involved the government, SEC or investors.	Establishment of broader cooperation between related stakeholders, such as plantation companies and energy development companies in the form of BOT (build operate transfer) or BOO (build operate owner), investment companies and government.
	Energy supply is still limited to meet the electricity needs of plantation companies.	Increased generating capacity in accordance with the electricity needs of the community.
	Limitations of oil palm plantation and agro-industries companies in the provision of investment capital, low technical capacity of human resources in operation and management of power plants. Low interest of investors in the construction of power plants if the palm oil mill production capacity of less than 30 tonnes of FFB/day. High reliance on plantation companies, especially in maintaining the continuity of raw material supply of energy sources.	Increased capability of oil palm plantation companies and agro-industries in waste processing into alternative energy. Provision of electricity generation development budget by government, investors or by banking institutions with a soft loan system in the time period can be agreed upon between both parties Establishment of supply chain synergies within a consortium involving various parties that have existed, ranging from plantation companies, energy development companies, and capital providers. Establishment of an independent company that is given special authority in the management of plantations to supply electricity to the community through the utilization of waste or palm oil biomass. The provision of special land as a place for the construction of a power plant that is separate from the production activities of the plantation company.
(Technical) Distribution and sale of electricity to communities	The payback rate has not been balanced between the value of investment and the number of customers in rural areas.	Granting access rights to palm oil companies or energy developers to sell electricity directly to communities around the region.
	The construction of the electrical grid installation is the responsibility of the plantation company or energy developer, thus requiring additional investment.	Conduct funding collaboration between plantation companies and SEC with budget allocation and revenue sharing in accordance with the agreement. Involving third parties (other institutions) in the provision of budget for the installation of power grids from power plants to customers (communities)

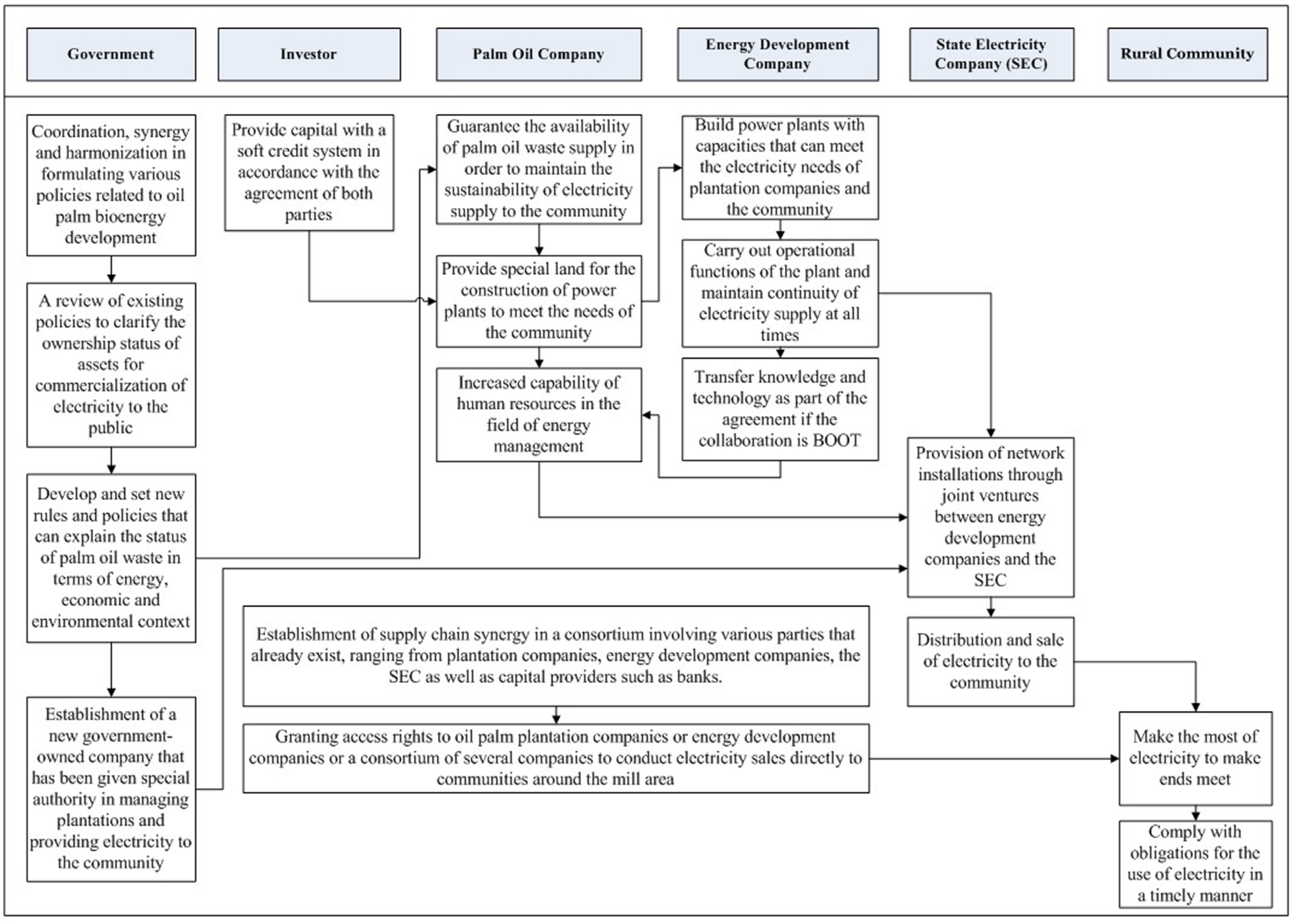

Fig. 10 Action plan diagram for problem solving

4.2 Determination of an adaptive institutional model

The determination of the institutional model has been done by using the Fuzzy AHP Method (F-AHP). The use of this method aims to determine the model of institutions that play a role in the development and utilization of palm oil biomass to meet the electricity needs of rural communities. In this study, the decision hierarchy is divided into three levels: 1st level for decision criteria, 2nd level for interest groups of actors, and 3rd level is an alternative decision, which is the institutional model to be selected.

In the first hierarchy, decision criteria are divided into five criteria, consisting of:

1. availability of capital and investment;
2. the ability of bioenergy supply of raw materials;
3. technological resource mastery capability;
4. availability of adequate land;
5. support of various stakeholders.

For second hierarchy, stakeholders are divided into six actors, consisting of:

1. Ministry of Energy and Mineral Resources;
2. local government;
3. oil palm plantation companies;
4. palm oil agro-industry companies;
5. energy development companies;
6. the national electricity company (SEC).

While the third hierarchy, alternative decision to be selected, consists of four institutional alternatives, namely:

1. converting one of the State-Owned Enterprises or Regional Owned Enterprises engaged in the field of palm oil agro-industry;
2. the establishment of a new or specialized organization or company;
3. the establishment of a consortium among related parties, such as government, private and State Electricity Companies; and
4. the implementation of BOP (build operate transfer) or BOO (build operate owner) cooperation between oil palm plantation and/or processing company with one energy development company.

Fuzzy AHP analysis has managed to aggregate expert judgments into a weighted value. The weight value gives an indication of priority for each level, either on criteria level, actor or decision alternative. At the criteria level, the highest weight that has been obtained is on the 3rd criterion, namely the ability of human resources in the mastery of technology, with the weight value of 45.45 %. Meanwhile, at the level of actors, stakeholders considered to be most instrumental in the development and utilization of palm oil biomass to meet the electricity needs of the community is the fifth actor, the energy development company, with a weight of 21.1 %. While the alternative decision of the selected institutional model is through the formation of a special and new energy developer company, with a weight value of 31.79 %. Overall, the weighted values of each criterion, stakeholders and decision alternative, are presented in Fig. 11.

The palm oil bioenergy-based power plant development program is an activity that involves a variety of stakeholders. Each party has their respective roles and responsibilities for the distribution of electricity to the community. Institutionally, this program requires stakeholders including:

1. the government (central and regional);
2. oil palm plantation and processing companies;
3. energy development companies;
4. the State Electricity Company (SEC);
5. financial institutions, and
6. the community.

The government has an important role in the formulation and determination of rules and or policies that support efforts to develop and use palm oil bioenergy. Some steps that need to be taken by the government include:

1. synergy and coordination in the context of harmonizing various policies and regulations;
2. reviewing, revising or adjusting various rules and policies;
3. formulate and set policies and rules for each institution that lead to a common goal related to the supply of bioenergy raw materials, the development and utilization and commercialization of electricity to the public;
4. coordinate in determining the forms of cooperation between related institutions or the establishment of implementing organizations for the development and utilization of palm oil bioenergy.

Palm oil companies have a very vital role, especially in ensuring the availability of bioenergy raw material supplies. The construction of a power plant certainly requires the availability of special land whose existence does not interfere with important activities in the palm oil processing company and is in a location that can facilitate the supply of bioenergy raw materials and the distribution of electricity to the community. To be able to carry out the development and utilization of palm oil bioenergy for electricity, plantation and palm oil processing

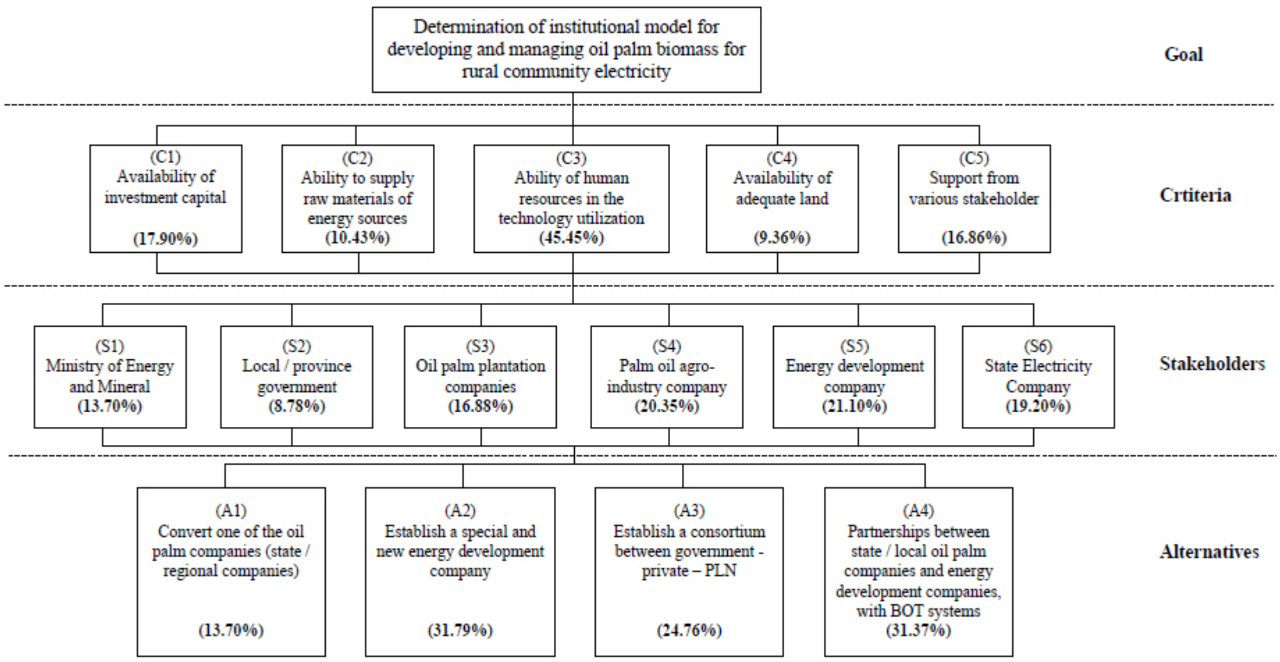

Fig. 11 Decision hierarchy diagram of the institutional model

companies also need to improve the capability of human resources, especially in the management of power plants and maintenance.

Related to efforts to provide the electricity supply through the utilization of palm oil bioenergy, each actor has their respective functions and roles. Each role is divided into strategic or technical role levels. The strategic role is closely related to policy and regulatory issues that govern the rules of the game, synergy and coordination between related institutions. The central government and regional governments have an important role in developing and formulating various rules that can support efforts to develop and use palm oil biomass as the main raw material for power generation. The relationship of institutional governance of the various organizations involved in the development and utilization program of palm oil bioenergy for electricity community can be described as shown in Fig. 12.

However, the development of palm oil as an energy source is a separate issue for plantation companies or palm oil processing companies, bearing in mind that their business orientation is more focused on palm oil production. Therefore, there needs to be support from other parties who have technical and operational capabilities in the development and utilization of the potential of palm oil bioenergy, in this case energy development companies or technically referred to as Independent Power Producers (IPP). IPP has an important role in providing technology, building and operating power plants, maintaining the stability of electricity supply and continuously providing electricity for the needs of both palm oil companies and the community. The role of IPP will be stronger with the support of the government, one of which is by the Agency for the Technology Development and Application Agencies (TDAA).

Commercialization of electricity to the public is currently still the authority of the government entrusted to the SEC. Therefore, related to the sale and distribution of electricity to the public, it is necessary to build coordination, cooperation and agreement between the energy development company and the SEC. Matters that need to be further agreed between the two parties are related to investment in power plant construction, investment in the construction of electricity transmission networks that connect power plants to public customers, selling prices and profit sharing, asset ownership rights and the duration of cooperation between the two parties. The agreement between the two parties greatly influenced the sustainability of the program.

The fundamental obstacle that also becomes a problem in the development and utilization program of palm oil bioenergy to meet the electricity needs of the community is in terms of investment and funding. To build a palm oil-based bioenergy power plant requires substantial investment, on the other hand the rate of return is still relatively low if the plant is built in an isolated area with a small number of customers or communities. Therefore funding support is mainly very dependent on the government, which is generally budgeted in the state budget or regional budget. As an alternative, funding sources can also be obtained from lending cooperation contracts to banking institutions or other investment companies. In addition, if possible funding support can also be obtained through budget submissions to the relevant ministries in this case the finance ministry. At present, for the management of oil palm plantation funds at the Ministry of Finance, the Oil palm Plantation Fund Management Agency (OPFMA) has been formed. The existence of OPFMA is expected to provide support not only to strengthen funds for plantation companies at the upstream level, but is also expected to be able to provide financial support for production needs, increase productivity in the form of subsidies and funding support for energy commercialization.

To carry out the development and utilization program for palm oil bioenergy, it is necessary to establish an implementing organization that plays a role in various matters, ranging from land preparation, supply of raw materials, provision of infrastructure and technology, provision and improvement of resource capabilities, transformation of raw materials (biomass) into electrical energy and so on channeling energy to the community. The existence of an implementing organization is very important in bridging the roles and abilities of various parties for the implementation of the development and utilization of palm oil bioenergy to meet the electricity needs of the community.

The establishment of special institutions is one alternative that can be pursued through coordination between the central government and regional governments, or between the government and the private sector. Through the establishment of special institutions, it is hoped that organizational management can become more independent, more focused and directed so that it can produce more optimal output. Specific institutions can be in the form of business entities whose management is regulated in certain rules and regulations drawn up by the government with the knowledge of the relevant parties including business actors and the community. Specific institutions that

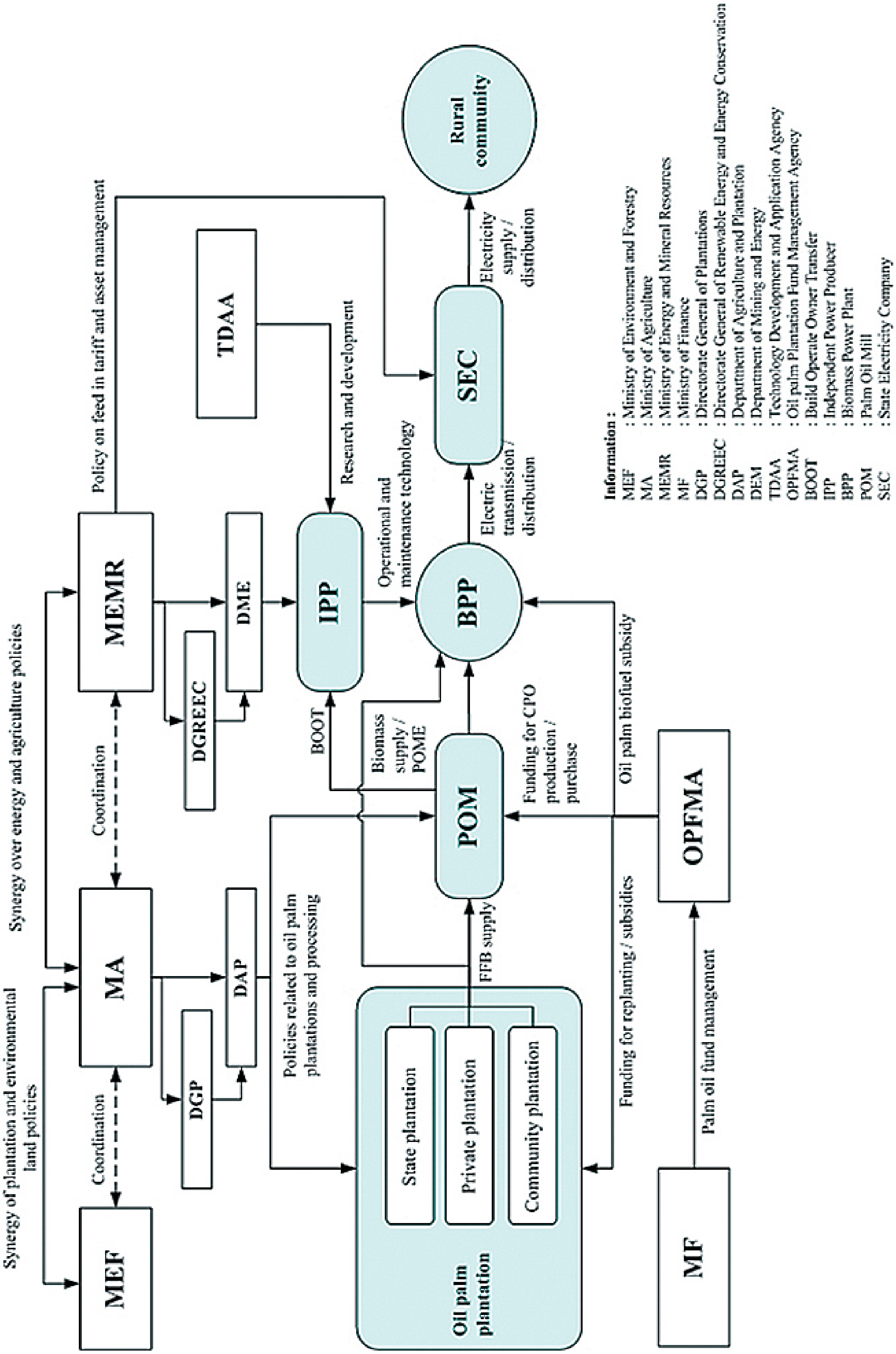

Fig. 12 Institutional relationship diagram

are formed can be institutions that are under the auspices of the regional government, in this case Regional-Owned Enterprises (ROE) or private organizations deemed appropriate and authorized by the government, selected through a strict and transparent assessment mechanism.

5 Conclusions and recommendations

This research has succeeded in identifying the fundamental issues that have influenced the development and utilization of palm oil-based bioenergy to meet the electricity needs of rural communities. Through analysis with the Soft System Methodology approach, the application of the CATWOE Method has identified the various factors and institutional problems of each stakeholder. Each problem has also been grouped by level, strategic, tactical and technical. The strategic level covers issues related to policies, rules, and coordination between institutions. Policies that still need to be reviewed include those relating to the status of palm oil biomass seen from the energy and environmental context, policies related to asset ownership and policies related to the commercialization of electricity to the communities. Then at the tactical level, several emerging issues are related to inter-institutional governance relations, partnerships, and cooperation, investment capital, raw material resource requirements, human resource capacity, land availability. While the problems at the technical level are related to the operation of the power plant, the construction of electricity network infrastructure, distribution and sale of electricity to the public.

The application of Hard System Methodology techniques has strengthened the results of the analysis to be more structured and measurable. Through the use of ISM techniques various elements have been identified and are grouped into four main elements, namely the elements of the program needs, elements of major constraints, elements of purpose and elements of supporting factors. Application of ISM technique by measuring the value of the drive-power, have also identified three key sub-elements of the program needs element, consisting of:

1. the availability of human resources and technology;
2. availability of investment capital;
3. support the various parties concerned, one key sub-element in the major constraint element, namely the large investment that must be provided, one key sub-element on the element of interest, namely the improvement of the status of sustainability of bioenergy development in Indonesia and two key sub-elements in supporting factor element, consisting of availability of palm oil factories spread throughout the district and ensuring continuity of bioenergy feedstock supply.

The application of F-AHP has also succeeded in getting an adaptive institutional model of the four offered models. The choice of institutional model is applied hierarchically by measuring the importance of weight value of 5 criteria and 6 stakeholders. The adaptive institutional model that is considered appropriate is to build a special institution that plays a role in the provision of raw materials, the construction of power plants and transformation into electrical energy, running the operation and management, the distribution and sale of electricity to rural communities.

As a recommendation, this research needs to be continuously developed. Some of the issues that need to be further researched include the analysis and compilation of integrated policy models with attention to various important aspects, such as objectives, needs, and constraints, the feasibility analysis of programs based on various aspects such as economic, social and environmental ones, multi-stakeholder role analysis in the success of the program and the determination priority energy sources that are more economical and environmentally friendly.

References

Ansori Nasution, M., Herawan, T., Rivani, M. (2014) "Analysis of Palm Biomass as Electricity from Palm Oil Mills in North Sumatera", Energy Procedia, 47, pp. 166–172.
https://doi.org/10.1016/j.egypro.2014.01.210

Arifin, B. (2005) "Ekonomi kelembangaan pangan" (Food institutional economics), Faculty of Agriculture, Lampung University, Jakarta, Indonesia, Rep. LP3ES. [online] Available at: https://repository.lppm.unila.ac.id/id/eprint/8472 [Accessed: 19 March 2018] (in Indonesian)

Attri, R., Dev, N., Sharma, V. (2013) "Interpretive Structural Modelling (ISM) approach: an overview", Research Journal of Management Science, 2(2), pp. 3–8.

BPS (2016) "Riau Province in Figure 2016", BPS-Statistics of Riau Province, Pekanbaru, Indonesia.

Bunch, M. J. (2003) "Soft Systems Methodology and the Ecosystem Approach: A System Study of the Cooum River and Environs in Chennai, India", Environmental Management, 31(2), pp. 182–197.
https://doi.org/10.1007/s00267-002-2721-8

Chang, D. Y. (1996) "Applications of the extent analysis method on fuzzy AHP", European Journal of Operational Research, 95(3), pp. 649–655.
https://doi.org/10.1016/0377-2217(95)00300-2

Checkland, P. (2000) "Soft Systems Methodology: A Thirty Year Retrospective", Systems Research and Behavioral Science, 17, pp. S11–S58.

Dharmayanti, I. (2015) "Desain Model Pengembangan Klaster Industri Hilir Kelapa Sawit di Kawasan Industri Sei Mangkei" (Model Design Development of Palm Oil Downstream Industry Cluster in Sei Mangkei Industrial Estate), Doctoral Dissertation, IPB University. (in Indonesian)

Directorate General of Electricity (2016) "Kebijakan pemerintah dalam pembangunan infrastruktur penyediaan tenaga listrik" (Government policy in the development of electricity supply infrastructure), Directorate General of Electricity, Jakarta, Indonesia. (in Indonesian)

Directorate General of Estate Crops (2017) "Tree crop estate statistics of Indonesia 2017", Directorate General of Estate Crops, Ministry of Agriculture, Jakarta, Indonesia.

Directorate General of New Renewable Energy and Energy ConservationDNREEC (2016) "Statistik EBTKE 2016" (NREEC Statistics 2016), Directorate General of New Renewable Energy and Energy Conservation, Ministry of Energy and Mineral Resources, Jakarta, Indonesia. (in Indonesian)

Enreach (2016) "Roadmap Listrik Desa Provinsi Riau Tahun 2017-2021" (Riau province village electric roadmap 2017-2019), Energy Research Center (Enreach), Pekanbaru, Indonesia. (in Indonesian)

Eriyatno (2013) "Ilmu Sistem: Meningkatkan integrasi dan koordinasi manajemen" (Systems Science: Improve management integration and coordination), Center for System Bogor, Bogor, Indonesia. (in Indonesian)

Fadhil, R., Maarif, M. S., Bantacut, T., Hermawan, A. (2017) "Model Strategi Pengembangan Sumber Daya Manusia Agroindustri Kopi Gayo dalam Menghadapi Masyarakat Ekonomi ASEAN" (Strategy Model for Gayo Coffee Agroindustry Human Resource Development in Facing the ASEAN Economic Community), Jurnal Manajemen Teknologi, 16(2), pp. 141–156. (in Indonesian) https://doi.org/10.12695/jmt.2017.16.2.3

Genus, A., Mafakheri, F. (2014) "A neo-institutional perspective of supply chains and energy security: Bioenergy in the UK", Applied Energy, 123, pp. 307–315. https://doi.org/10.1016/j.apenergy.2014.01.084

Henggeler Antunes, C., Dias, L., Dantas, G., Mathias, J., Zamboni, L. (2016) "An Application of Soft Systems Methodology in the Evaluation of Policies and Incentive Actions to Promote Technological Innovations in The Electricity Sector", Energy Procedia, 106, pp. 258–278. https://doi.org/10.1016/j.egypro.2016.12.121

Ikatrinasari, Z. F., Maarif, S., Bantacut, T., Munandar, A., Gumbira Sa'id, E., Bantacut, T., Munandar, A. (2009) "Agroindustry based agropolitan institutional desing with Analytical Network Process", Jurnal Teknologi Industri Pertanian, 19(3), pp. 130–137.

Indonesia Republic of Government (2009) "Undang-undang Republik Indonesia Nomor 30 Tahun 2009, tentang ketenagalistrikan" (Law of the Republic of Indonesia Number 30 of 2009, concerning electricity), Indonesia Republic of Government, Jakarta, Indonesia. (in Indonesian)

Kusnandar, K., Padmaningrum, D., Rahayu, W., Wibowo, A. (2013) "Rancang bangun model kelembagaan agribisnis padi organik dalam mendukung ketahanan pangan" (Design agribusiness institutional models in organic to support food security), Jurnal Ekonomi Pembangunan, 14(1), pp. 92–101. (in Indonesian) https://doi.org/10.23917/jep.v14i1.163

Liu, W. B., Meng, W., Mingers, J., Tang, N., Wang, W. (2012) "Developing a performance management system using soft systems methodology: A Chinese case study", European Journal of Operational Research, 223(2), pp. 529–540. https://doi.org/10.1016/j.ejor.2012.06.029

Lolowang, T. F. (2012) "Rancang Bangun Model Pengembangan Klaster Agroindustri Aren di Sulawesi Utara" (Modelling Design for Cluster Plan of Sugar-palm Agroindustry in Sulawesi Utara), Doctoral Dissertation, IPB University. (in Indonesian)

Marimin, M., Djatna, T., Suharjito, S., Hidayat, S., Utama, D. N., Astuti, R., Martini, S. (2013) "Teknik dan Analisis Pengambilan Keputusan Fuzzy dalam Manajemen Rantai Pasok" (Fuzzy Decision Making Techniques and Analysis in Supply Chain Management), IPB Press, Bogor, Indonesia. (in Indonesian)

Mehregan, M. R., Hosseinzadeh, M., Kazemi, A. (2012) "An application of Soft System Methodology", Procedia - Social and Behavioral Sciences, 41, pp. 426–433. https://doi.org/10.1016/j.sbspro.2012.04.051

Ministry of Agriculture (2015) "Peraturan Menteri Pertanian Republik Indonesia Nomor 11 Tahun 2015, tentang sistem sertifikasi kelapa sawit berkelanjutan" (Regulation of the Minister of Agriculture of the Republic of Indonesia Number 11 of 2015, about Indonesia Sustainable Palm Oil (ISPO) sertification), Ministry of Agriculture, Jakarta, Indonesia. (in Indonesian)

Ministry of Energy and Mineral Resources (2014) "Peraturan Menteri Energi dan Sumber Daya Mineral Republik Indonesia, Nomor 27 Tahun 2014, tentang pembelian tenaga listrik dari pembangkit listrik tenaga biogas oleh Perusahaan Listrik Negara (PLN)" (Regulation of the Minister of Energy and Mineral Resources of the Republic of Indonesia, Number 27 of 2014, regarding the purchase of electricity from biogas power plants by the State Electricity Company (SEC), Ministry of Energy and Mineral Resources, Jakarta, Indonesia. (in Indonesian)

Ministry of Energy and Mineral Resources (2017a) "Peraturan Menteri Energi dan Sumber Daya Mineral Republik Indonesia, Nomor 39 Tahun 2017, tentang kegiatan fisik pemanfaatan energi baru dan terbarukan serta konservasi energi" (Regulation of the Minister of Energy and Mineral Resources of the Republic of Indonesia, Number 39 of 2017, concerning physical activities for the use of new and renewable energy and energy conservation), Ministry of Energy and Mineral Resources, Jakarta, Indonesia. (in Indonesian)

Ministry of Energy and Mineral Resources (2017b) "Peraturan Menteri Energi dan Sumber Daya Mineral Republik Indonesia, Nomor 50 Tahun 2017, tentang pemanfaatan sumber energi terbarukan untuk penyediaan tenaga listrik" (Regulation of the Minister of Energy and Mineral Resources of Number 50 of 2017, concerning the use of renewable energy for electricity supply), Ministry of Energy and Mineral Resources, Jakarta, Indonesia. (in Indonesian)

Nidumolu, U. B., de Bie, C. A. J. M., van Keulen, H., Skidmore, A. K., Harmsen, K. (2006) "Review of a land use planning programme through the soft systems methodology", Land Use Policy, 23(2), pp. 187–203.
https://doi.org/10.1016/j.landusepol.2004.08.003

Novani, S., Sarjono Putro, U., Hermawan, P. (2014) "An Application of Soft System Methodology in Batik Industrial Cluster Solo by using Service System Science Perspective", Procedia - Social and Behavioral Sciences, 115, pp. 324–331.
https://doi.org/10.1016/j.sbspro.2014.02.439

Papilo, P., Bantacut, T. (2016) "Klaster industri sebagai strategi peningkatan daya saing agroindustri bioenergi berbasis kelapa sawit" (Industrial cluster as a strategy to increase the competitiveness of palm oil-based bioenergy agro-industry), Jurnal Teknik Industri, 11(2), pp. 87–96. (in Indonesian)
https://doi.org/10.14710/jati.11.2.87-96

Papilo, P., Kusumanto, I., Kunaifi, K. (2017) "Assessment of agricultural biomass potential to electricity generation in Riau Province", IOP Conference Series: Earth and Environmental Science, 65(1), Article Number: 012006.
https://doi.org/10.1088/1755-1315/65/1/012006

Pfohl, H. C., Gallus, P., Thomas, D. (2011) "Interpretive strucutural modeling of supply chain risk", International Journal Physical Distribution & Logistic Management, 41(9), pp. 839–859.
https://doi.org/10.1108/09600031111175816

Presley, A., Sarkis, J., Liles, D. H. (2000) "A Soft-Systems Methodology Approach for Product and Process Innovation", IEEE Transaction on Engineerging Management, 47(3), pp. 379–392.
https://doi.org/10.1109/17.865906

Purnomo, H. (2012) "Pemodelan dan simulasi untuk pengelolaan adaptif sumber daya alam dan lingkungan" (Modeling and simulation for adaptive management of natural resources and the environment), IPB Press, Bogor, Indonesia. (in Indonesian)

Saaty, T. L. (2008) "Decision making with the analytical hierarchy process", International Journal of Service Science, 1(1), pp. 1–8.
https://doi.org/10.1504/IJSSCI.2008.017590

Saptono, I. T., Marimin, M., Tambunan, M., Oktaviani, R. (2010) "Desain lembaga pertanian nasional subsektor tanaman pangan menggunakan pendekatan Intepretative Structural Modeling (ISM)" (Design of the national agricultural institution of food crop subsector using Interpretative Structural Modeling (ISM) Approach), Jurnal Manajemen & Agribisnis, 7(2), pp. 84–96. (in Indonesian)
https://doi.org/10.17358/jma.7.2.84-96

Saxena, J. P., Sushil, Vrat, P. (1992) "Hierarchy and classification of program plan elements using interpretive structural modeling: A case study of energy conservation in the Indian cement industry", System practice, 5(6), pp. 651-670.
https://doi.org/10.1007/BF01083616

Sgourou, E., Katsakiori, P., Papaioannou, I., Goutsos, S. (2012) "Using Soft Systems Methodology as a Systemic Approach to Safety Performance Evaluation", Procedia Engineering, 45, pp. 185–193.
https://doi.org/10.1016/j.proeng.2012.08.141

Shega, H. N. H., Rahmawati, R., Yasin, H. (2012) "Penentuan faktor prioritas mahasiswa dalam memilih telepon selular dengan Fuzzy AHP" (Determination of student priority factors in choosing a cellular phone with Fuzzy AHP), Journal Gaussian, 1(1), pp. 73–82. (in Indonesian)

Soemartono, T. (2014) "Reconstruction of Education Policy in Jembrana Bali, Best Practices of Creative and Innovative Leadership using Soft Systems Methodology based Action Research", Procedia - Social and Behavioral Sciences, 115, pp. 269–282.
https://doi.org/10.1016/j.sbspro.2014.02.435

Syahyuti (2002) "Kelembagaan dan keorganisasian pertanian. Konsep, hasil-hasil penelitian, dan strategi pengambangannya" (Institutional and organizational agriculture. The concept, the results of research, and the floating strategy), Pusat Penelitian dan Pengembangan Sosial Ekonomi Pertanian, Jakarta, Indonesia. (in Indonesian)

Talib, F., Rahman, Z., Qureshi, M. N. (2011) "Analysis of interaction among of barriers to total quality management implementation using interpretive structural modelling approach", Benchmarking: An International Journal, 18(4), pp. 563–587.
https://doi.org/10.1108/14635771111147641

Udayana, I. B., Eriyatno, Hambali, E., Fauzi, A. M. (2010) "Management risk biodiesel agroindustry based on palm oil", Agritek, 11(2), pp. 10–20.

Uphoff, N. T. (1986) "Local institutional development: an analytical sourcebook with cases", Kumarian Press, West Hartford, CT, USA. [online] Available at: https://www.cabdirect.org/cabdirect/abstract/19876704948 [Accessed: 23 April 2018]

Wang, W., Liu, W., Mingers, J. (2015) "A systemic method for organisational stakeholder identification and analysis using Soft Systems Methodology (SSM)", European Journal of Operational Research, 246(2), pp. 562–574.
https://doi.org/10.1016/j.ejor.2015.05.014

Wisena, B. A., Daryanto, A., Arifin, B., Oktaviani, R. (2014) "Sustainable development strategy for improving the competitiveness of palm oil industry", International Research Journal of Business Studies, 7(1), pp. 13–37.
https://doi.org/10.21632/irjbs.7.1.13-37