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Energy resilience assessment by using SEM approach in the Central Java Province, Indonesia

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Abstract

Energy is one of the critical infrastructure for urban and rural development. Although planning and management of the energy provision tend to centralized, the role of local stakeholder is very significant to achieve energy resilience. An assessment of energy resilience is not only related to the disaster condition, but also associated to any effort to solve of uncertainties in normal condition such as supply shortages, low level of ratio electrification, consistency of provision and standardization. This study defined that energy resilience are influenced by five factors namely, stakeholder effort to understand their needs, effort to understand process of energy provision, effort to understand the facility of energy provision, effort to understand efficiency energy consumption and the behaviour to achieve, and the local government concern. By using SEM approach this study examined a model of the five factors that affect resilience energy. According to the assessment from the 8,528 villages in Central Java province of Indonesia, this study founded that the five factors were evidently influence in energy resilience achievement.

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Keywords:Energy resilience assessment; provincial and local government preparedness; structural equation modelling (SEM).

1. Introduction

Energy is one of the critical infrastructure for urban and rural development. Access enough of energy is very essential to reduce poverty that in turn increasing community resilience in this uncertainty era such as global climate

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change trends and unpredictable of natural disaster. The sustainability of the energy provision should cover any possibility of increasing demand both in normal and disaster situation. Resilience and sustainable of energy is not only providing the quantity but also ensuring the distribution and balancing of the modern equipment of energy in urban and rural. In 2015, International Bank for Reconstruction and Development/The World Bank stated that there were around 1.1 billion people without access of electricity and 2.9 billion people use non modern equipment and utilize solid fuel such as wood, charcoal, coal, and dung for cooking. The goal of the study is to examining the hierarchical factor model that depicts provincial and local stakeholder creation to improve the energy resilience. This study assesses the effort of stakeholder to understand the importance of energy access to the social growth and poverty countermeasures.

Application of the resilience concept is vary depending on the field, such as socio-ecological socio-economic, engineering and disaster management. In energy, Matzenbergeret al., (2015) defined that energy resilience is an ability the system to cope with and maintain the function from the disruptions and possibility of system to exploit positive opportunity to increase or develop the capacity of system. Sharifia, A., &Yamagatab, Y., (2015) introduced energy resilience assessment in the urban level by proposing the criteria of availability, accessibility, affordability, and acceptability. This study combines the two terms of energy resilience, however this study stressing the stakeholder in provincial and local state effort to increase the capability of energy provision in rural level.

2. Method

2.1. Literature review of energy resilience model

Energy requirement is the fundamental aspect on discussing energy resilience. For the basic planning and management in urban and rural development, energy requirements can be adapted from FAO (2001) assessment, that energy requirement can be estimated from measures energy expenditure and additional energy for growth. There were some variables that affect energy requirement such as the growth of population, the life style of the population (Lensen, M , et. al, 2006). The other condition that affects energy resilience is disruption in the location such as disaster event. Since the Planning such as developing scenario of energy needs both in normal condition and disaster event tend to centralized, the effort of local stakeholder to understand and then involve in the planning and management scheme is very essential to achieve the resilience.

Energy supply describes the performance of energy delivery to the point of consumption. Energy supply also indicates the capability of stakeholder to transfer, transport and storage of energy on a period of time. Access of energy should cover all human activity to improving the quality of life in urban and rural. The disruption of energy supply generates both from the delivery process and capability to receive. Understanding of the process of energy provision such as examined stakeholder effort to mapping the unbalance of the distribution of energy provision become one of the importance latent factors of energy resilience. The issues of energy distribution and balancing can be described from the access to energy at house hold (Jorgenson, et. Al, 2010) and poor people (Karekezi, et al, 20 The key performance of the criteria in this latent factor is consistency and standardization of the provision.

Goldthau, A. (2014) stated that rethinking of the governance of energy infrastructure provision was an essential stage in recent decade to achieve a sustainable of energy provision. There are two main classification of energy infrastructure provision in urban rural. The hard infrastructure at which associated to the physical or technical exploration, production and distribution. The other is soft infrastructure such us information of stock information of delivery. Since the management of delivery then to centralized, the role of local stakeholder to bridges between producer and consumer influence the energy resilience. This study also assess the stakeholder understanding of their responsibility for enhance sufficient energy infrastructure.

Even though behavior of consumption to perform energy efficient demand is worldwide recognized, stakeholder effort to understand and find a novelty and breakthrough is waited. Even though Luaren (1992) stated that very difficult to build a satisfactory model to describe consumption behavior of energy, Stephenson, et. al (2010) has developed a model to identifying opportunity in changing behavior of energy consumption. This study examined that the behavior of energy consumption of energy was describes by community behavior in use of non-modern energy equipment such as use the solid fuel (wood) to fulfill their requirement. Level of education was used to assess the

stakeholder effort to changing the energy consumption behavior, such as the performance or number of community who get access formal education.

The consistency of energy policy from central government was very significant to achieved energy resilience. Since stated by Guy & Marvin (1996) that there is a disconnected policy on energy management both positive and negative impact to achieve sustainable energy management, research toward local government awareness to the energy become large. Local government is the first layer to filter the relationship between community and central government at which hold a main key on design energy policy. Beside local government must transform the energy policy to the local community, local government have responsible to ensure all level of community get a sufficient access of energy requirement. The local government concern according to the resilience of energy was proposed in this model to describe and reinventing the effort of local government in mitigation and preparedness of energy resilience.

2.2. Structural equation modelof energy resilience

This study examined hypothesis that energy resilience are influence by stakeholder effort to understand their needs, effort to understand process of energy provision, effort to understand the facility of energy provision, effort to understand efficiency energy consumption and the behavior to achieve it, and the local government concern. The hierarchical factor model of energy resilience consists of two main model, measurement model and structural model, depicted in figure 1.

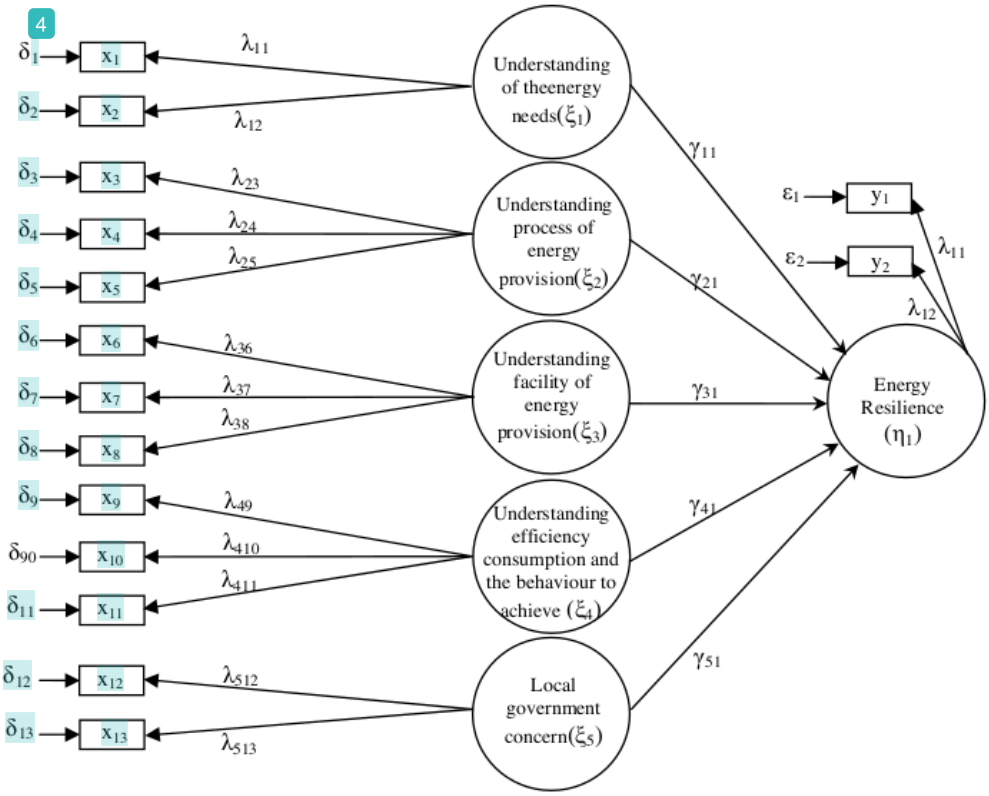


Fig. 1.Full hierarchy structural equation model of energy resilience, depicted as a path diagram, hybrid with mathematical symbols.

Table 1. Mathematic symbol of measured variables and data requirement

Mathematic symbol of measured variables	Explanation of measured variable and data requirement
x_1	Population
x_2	Disaster event
x_3	Household with no electricity
x_4	Degree of slum area
x_5	Household agriculture labor
x_6	Road infrastructure condition
x_7	Internet access
x_8	Tv access
x_9	House hold with solid fuel model
x_{10}	Community/people got senior high school access
x_{11}	Type and access for informal education
x_{12}	Infrastructure development with participation pattern
x_{13}	Small scale economic development
y_1	Public space and street lighting
y_2	Disaster relief

There are two unobserved factor or latent variables (ξi), (η_1). The measurement model consists of factor model of (ξ_i) and factor model of (η_1). Factor model of (ξi) is a dependent variables which observed by variable xi, as sign by arrow from (ξ_i) to x_i, while factor model of (η_1) is dependent variables which observed variable y_i, as sign by arrow from (η_1) to y_i (Joreskog, 1993). The structural model is the regression between factor model of (ξ_i) and factor model of (η_1) as sign by arrow from (ξ_i) to (η_1). Observed variables of x_i and y_i described in table 1.

The analysis factor or measurement of the factor model of independent latent variable, dependent latent variable, and the regression independent and dependent latent variable of the model describe by the mathematic formula as below:

$$x_i = \lambda_{xi}\xi_{in} + \delta_i \quad (1)$$

$$y_i = \lambda_{yi}\eta_1 + \varepsilon_i \quad (2)$$

$$\eta_1 = \xi_1\gamma_{11} + \xi_2\gamma_{21} + \xi_3\gamma_{31} + \xi_4\gamma_{41} + \xi_5\gamma_{51} \quad (3)$$

Where,

x_i : Observed variable of ξ

y_i : Observed variable of η

ξ : Predictor latent variable (factor)

η : Dependent latent variable (factor)

λ_{xi} : Loading factor, a relation/path between predictor or dependent latent variable and observed variable

λ_{yi} : Loading factor, a relation/path between dependent latent variable an observed variable

γ_i : Regression/path predictor latent variable & dependent latent variable

ζ_i : Regression/path one dependent latent variable to others

δ_i : Error Measurement for x

ε_i : Error Measurement for y

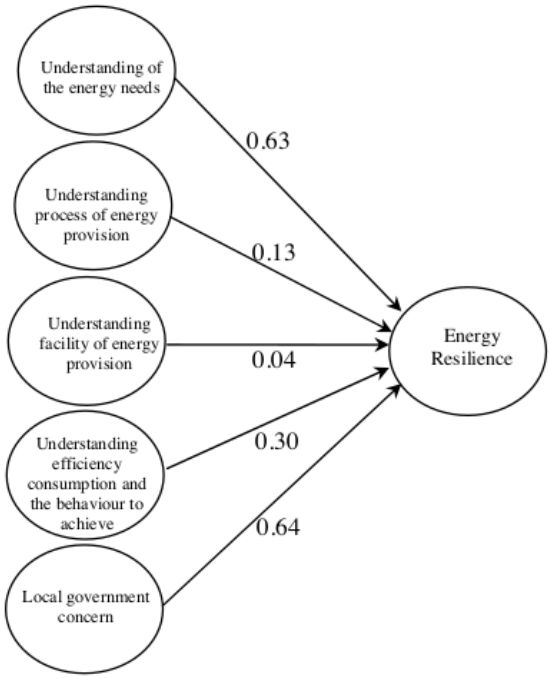
2.3. Location study and data requirement

Central Java Province is one of the strategic province in Indonesia, that hold in significant role the perform of energy resilience. From the demand view side, Central Java was dynamic place. Central Java province is also a prone province since many natural hazard hit, such as flood, earthquake, and volcano eruption. According the supply of energy, several exploration and production of energy conducted in Central Java such as Block Cepu oil exploration, Batang electric steam power plant and Dieng geothermal exploration. This study assessed 8,528 villages in Central Java province to examine the structural equation model of energy resilience.

3. Result and Discussions

This study is for continuing the assessment toward critical infrastructure in developing countries. We have been started to analysis infrastructure resilience in Thailand for waste management during flood (Nakayama et al, 2013). The next stage, we assessing the stakeholder preparedness toward disaster waste in Banda Aceh Indonesia (Maryono et al, 2015). This study is the third stage to understanding the SEM method in critical infrastructure resilience assessment. An assessment of the data has positive value. The model shown that the hypothesis of relation model between dependent and independent latent variable or arrow from the origin to the destination are validated. All factors with the hierarchical model hypothesis are influence the resilience of energy. Figure 2 depict the result of the model assessment.

According to the model assessment from the central Java villages, road infrastructure condition, internet access quality, tv access are not sufficient to describe the influence of latent variable of understanding facility of energy provision. Moreover, the degree of electricity in slum area and the degree of labor in agriculture sector also not sufficient to describe the latent factor of Understanding process of energy provision. In turn two latent variable relations with resilience energy are weak.



P –value = 0.000 ; RMSEA= 0.457

Fig. 2.Structural equation model of energy resilience in Central Java Province, Indonesia.

4. Conclusions

- This study proposed conceptual framework to access energy resilience according to the provincial and local government policy and preparedness.
- There are five conceptual indicator that can be used to assess energy resilience according to the provincial and local government policy and preparedness, namely;
  - Stakeholder effort to understand their needs,
  - Stakeholder effort to understand process of energy provision,
  - Stakeholder effort to understand the facility of energy provision,
  - Stakeholder effort to understand efficiency energy consumption and the behavior to achieve,
  - Local government concern.

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