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Energy Security Scenario based on Renewable Resources: A Case Study of East Sumba, East Nusa Tenggara, Indonesia

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Abstract. This study aims to analyze the state of energy security in East Sumba, one of the four regencies dividing the Island of Sumba, East Nusa Tenggara Province, Indonesia. This region was chosen for this study as it is popularly known as the Iconic Island of Renewable Energy. Data was gathered by applying expert interview method and analytical hierarchy process. In sum, 30 source persons dealing with the energy security issue were interviewed: 11 government officials (G), 8 businessmen (B), 5 scholars (A), 4 from the common society (C), and 2 from a financial institution. This study applied energy security index to assess energy security in East Sumba. The data was analyzed by using descriptive analysis and Eckenrode method, with energy security as a criterion. The study results show that the energy security index based on renewable resources in East Sumba is still relatively low (5.91). East Sumba is rich in natural sources of energy, such as sunlight, water, biomass, wind, and biogas. Factors such as poor affordability lead to a low energy security index in East Sumba, which is often a result of poverty. The natural vast hilly and grassland topography and the decentralized settlement of the people of East Sumba also lead to poor accessibility of energy. Moreover, the supporting infrastructure, such as roads, also causes a low index of energy security. The lack of an institutional model also discourages investors from investing in East Sumba. The electrification ratio in East Sumba is still low, reaching only 31%.

Keywords: Eckenrode, renewable energy, energy security index, East Sumba

Abstrak. *Penelitian ini bertujuan untuk menganalisis kondisi ketahanan energi di Sumba Timur yang akan dijadikan sebagai model untuk perancangan skenario zona ketahanan energi berbasis sumber daya alam terbarukan. Lokasi penelitian dilakukan di Sumba Timur, Pulau Sumba, Nusa Tenggara Timur. Lokasi ini dipilih karena telah ditetapkan sebagai Ikon Pulau Energi Terbarukan (The Iconic Island of Renewable Energy). Metode yang digunakan dalam penelitian ini adalah dengan wawancara pakar/praktisi di bidang energi sebanyak 30 orang di Sumba Timur dan Kupang Nusa Tenggara Timur yang mewakili instansi pemerintah (G) sebanyak 11 orang, pelaku usaha (B) (8 orang), akademisi (A) (5 orang), masyarakat (C) (4 orang), dan lembaga keuangan sebanyak 2 orang. Penelitian ini menggunakan analisis deskriptif dan metode Eckenrode dengan kriteria ketahanan energi. Hasil penelitian menunjukkan bahwa indeks ketahanan energi berbasis sumber daya alam terbarukan di zona Sumba Timur secara keseluruhan masih relatif rendah (5.91). Ketersediaan energi berbasis sumber daya alam di Sumba Timur memiliki nilai yang cukup tinggi, sumberdaya alam yang ada di Sumba Timur terdiri dari energi surya, air, biomassa, angin dan biogas. Rendahnya indeks ketahanan energi di Sumba Timur disebabkan beberapa hal, di antaranya Affordability (keterjangkauan) masyarakat yang masih rendah karena sebagian besar masyarakat di Sumba Timur merupakan masyarakat miskin. Akses untuk mendapatkan energi juga masih sulit, hal ini karena topografi yang berbukit dan padang rumput serta permukiman penduduk yang terdesentralisasi, sedangkan Sumba Timur memiliki wilayah yang luas. Infrastruktur pendukung seperti jalan raya menjadi salah satu faktor rendahnya indeks ketahanan di Sumba Timur, dan belum terbentuknya model kelembagaan. Hal ini menyebabkan sulitnya investor untuk berinvestasi di Sumba Timur. Rasio elektrifikasi Sumba Timur juga masih rendah baru mencapai 31%.*

Kata kunci*: Eckenrode, energi terbarukan, indeks keamanan energi, Sumba Timur*

INTRODUCTION

According to the total final energy consumption (TFEC), in 2013 (ACE, 2015), Indonesia was classified as the largest consumer of energy (38%) among the Association of Southeast Asian Nations countries. Among more than 17,000 islands, TFEC, excluding non–energy consumption in Indonesia, accounted for 7.3 EJ in 2014, an increase of more than 201% since 2010 (Indonesian Ministry of Energy and Mineral Resources, 2015). To date, fossil fuel remains the main source of the energy consumed. However, fossil fuel reserves are getting depleted over time, and this type of fuel also causes global and local environmental damage. One of the indicators of environmental damage is the emission of CO2, which leads to air pollution. In 2012, the air pollution index rose to 1.4%, corresponding to 31.6 GT of CO2 emissions (CNN Money, 2013).

The high consumption of energy and energy scarcity are inherent not only to Indonesia, but also to all other countries in the world. The high demand for energy is driven by the industrial growth as well as the growth of the population. However, crude oil supplies remain unchanged; thus, the prices of crude oil tend to fluctuate and even rise, the impact of which on a nation and on its people is quite significant. Therefore, renewable energy such as solar energy, wind energy, tidal wave energy, bioenergy, and biofuel (bioethanol, biogas, bioether, biogasoline, and biodiesel) has been developed to reduce energy consumption and deal with the issue of energy scarcity.

Given Indonesia's vast areas, the government cannot manage investments in renewable energy development alone. Given the several hindering factors, it is imperative to involve the private sector in developing renewable energy because of their flexible access to capital, advanced technology, and innovation in this area.

In the present study, we consider the Island of Sumba as our case study. Owing to the limited research time, we focus in this study on East Sumba. This island was chosen for the present study because it was chosen as the Iconic Island of Renewable Energy in Indonesia, which was initiated in 2010 by the Ministry of Energy and Mineral Resources and Hivos. The aim of this program is to increase access to energy to those residing in small- and medium-sized islands in Indonesia. Renewable energy is expected to fulfill 100% of the energy requirements in the future.

Hivos/Winrock International conferred the title of the Iconic Island of Renewable Energy on Sumba Island because it has low access to the modern sources of energy, with just 24.5% electrification in 2010. The island of Sumba depends on a diesel power plant, which supplies 85% of the electricity in another area. Therefore, this island relies mostly on renewable energy resources, such as water, bioenergy, wind, and sunlight. Based on these factors, in the present study, we analyze the state of energy security in East Sumba prior to designing a model for a local renewable energy security scenario.

RESEARCH METHOD

A quantitative approach is adopted in this study. This study was conducted over five days from September 4 to September 9, 2018, by distributing questionnaires and conducting interviews with experts/key people in both East Nusa Tenggara Province and East Sumba Regency. This study involved all stakeholders in an effort to strengthen the role of the private sector in developing energy security rooted in renewable energy in Kupang, the capital city of Nusa Tenggara Timur Province, and in East Sumba Regency. The interviewees are coming from experts and various stakeholders from the government, both the Provincial Government of East Nusa Tenggara (in this case the Provincial Research and Development Units and Energy and Mineral Resources Agency) and Regency Government of East Sumba (Regional Development Planning Agency, Research and Development Units, one-stop integrated service). Scholars in the field of renewable energy were selected from Kupang State Polytechnic and the University of Nusa Cendana in Kupang. Other stakeholders included business practitioners in different energy sectors, such as the State Electricity Corporation and private corporations, social figures, nongovernmental organizations (NGOs), and financial institutions. In sum, 30 source persons dealing with the energy security issue were interviewed: 11 government officials (G), 8 businessmen (B), 5 scholars (A), 4 from the common society (C), and 2 from a financial institution.

Open-ended questionnaires and in-depth interviews on energy security with key people were used for descriptive analyses, and the Eckenrode method with the criterion of renewable energy security was used for quantitative analyses.

The data was analyzed by using descriptive analysis and Eckenrode method with energy security as a criterion. Energy security can be defined as the availability of sufficient energy at an affordable price. This definition has directed policies and world energy hegemony from the 1970s to the 2000s. A recent paradigm shift modified the definition to include not just the availability of supply, but also sustainability and security in acquiring and managing energy resources. The concept of energy security, involving environmental impact, motivates the development of renewable energy technologies, which will lead to energy conservation.

Based on the data from Asia Pacific Energy Research Centre (APERC), several energy security indicators, such as availability, affordability, accessibility, and acceptability, that is, the 4As, are considered. Components and indicators are also based on the data obtained from the World Energy Council, Agency for Technology Assessment and Application and National Resilience Institute (NRI) of Republic of Indonesia, which can be further added, cut, or revised.

The indicators of energy security based on dominant variables are as follows:

(1) Availability

The availability of energy is related to fossil energy, such as oil, natural gas, and coal, or renewable energy, such as sunlight, wind, waste, and micro hydro. The following factors are considered: a) Use of new and renewable energy for national power plants: It is important to shift usage from fossil energy to renewable energy because fossil energy is expensive and is in limited supply; b) Contribution of energy export to energy security: Energy is exported to earn foreign exchange, but it also greatly reduces the national energy supply; c) Contribution of energy import to energy security: Energy is imported to fulfill shortfalls in domestic production. However, it might affect the energy security; d) Diversification of energy consumption: Diversification will increase flexibility in the energy supply, thus improving the energy security.

(2) Affordability

The consumers' ability to pay for energy indicates the affordability and the price that needs to be set for developing energy infrastructures and energy management. It is closely related to the following factors: a) Energy consumption per capita: This factor indicates economic growth and the people's ability to purchase energy. Energy consumption includes both electricity and total energy consumption per capita; b) People's (economy's) ability: This shows the consumer's ability to pay for energy without subsidy.

(3) Accessibility

Accessibility is denoted by the convenience of accessing energy resources in the form of final energy. It is related to the following: a) Distribution capacity, which includes the production capacity of liquefied natural gas (LNG) refineries, receiving terminals, LNG plants' capacity, and power plants' capacity; b) The strategic reserve, which affects the quality of the energy supply and ensures energy supply sustainability.

(4)Acceptability

Acceptability shows the state in which energy is provided to the public. Public acceptance is related to the following: a) Environment: Renewable energy is in line with the government's program, which prioritizes low-emission energy programs, such as new, renewable energy utilization, as well as other efforts to boost sustainability or help the environment adapt to damage.

In addition to the 4As indicators, energy security is also measured through the kind of energy used by the public, the infrastructure, the level of energy utilization, and the environment. According to study of DEN (2015) and others, 18 indicators based on the 4As were further identified. Affordability includes energy productivity, gasoline and LPG prices, electricity prices, natural gas prices, and coal prices. Accessibility includes gasoline and LPG supply, electricity supply, natural gas supply, and coal supply. Availability includes gasoline and LPG import, crude oil import, domestic market obligation (DMO) for coal and natural gas, oil and gas reserve, coal reserve and availability, and renewable energy reserve. Acceptability includes energy mix target, reduction of greenhouse gas emissions, and public acceptance.

The energy security level is assessed on four scales: low (0–6), moderate (6–7), good (7–8), and high (8–10). Based on these indicators, using the analytic hierarchy process (AHP), Indonesia's energy security level scores stand at 7.518, categorized as "good."

According to the International Energy Agency (IEA, 2017), energy security is defined as the undisrupted availability of energy resources at an affordable price. Energy security is considered on long-term and short-term bases. Long-term energy security is related to timely investments to ensure energy supply in accordance with the economic growth and environmental needs, whereas short-term energy security focuses on the energy system's ability to respond instantly to sudden changes in the supply-and-demand equilibrium.

RESULTS AND DISCUSSION

The energy security index is the most important indicator of East Sumba's energy security scenario. We make East Sumba projected as a model of local renewable energy security and look at the condition and index based on a results of the interviews. The interviewees were allowed to justify their responses through a questionnaire in Table 1.

Table Information:

Rj: rank number j, j = 1, 2, 3, …, n.
Ki: criteria type number i, i = 1, 2, 3.
Jrij: number of respondents choosing ranking number j, for criterion number i.
Rn−j: multiplier number j, which is obtained from subtracting the rank order in the column from the number of criteria or number of ranks (n). For instance, there are five criteria, so the multiplier at the 3rd rank column (e.g., j = 3) is n–j = 5–3 = 2.
Bi: value of criterion number i.

The energy security index was analyzed by applying the following steps:

(1) Determine the weight of the energy security aspects, namely, affordability, accessibility, availability, and acceptability (4As), using the Eckenrode method. The Eckenrode weight was calculated as follows: a) The respondents were asked to rank every criterion, from R1 to Rn, if there is Rn. For instance, there are n rankings, j = 1, 2, 3, …, n = j rankings (Rj) for every criterion (i criterion, notated as Ki, which is numbered as many as n criteria, i = 1, 2, 3, …, n). The obtained data are displayed in Attachment 1.; b) According to Jrij and Rn−j, Ni is calculated as follows:
Ni = ∑j =1 Jrij × Rn−j, where j = 1, 2, 3, …, n,
Total value = ∑i = 1 Ni, where i = 1, 2, 3, …, n.
; c) Calculate the weight of criterion Bi (namely, B1, B2, and B3, …, n), where i = 1, 2, 3, …, n, using the following formula:
Bi = (Ni/total value).

Using the derived formula of Bi, the weight of each aspect or criterion of energy security (4As) is obtained and displayed in Table 2. Table 2 and the justifications presented by key respondents reveal that the weighted of the aspect of availability is the highest (0.406), followed by affordability (0.267), acceptability (0.178), and accessibility (0.15). This result indicates that affordability is the most important criterion in accomplishing renewable energy security. Renewable energy requires public acceptance as well, and finally renewable energy sources need to be accessible as well.

(2) Determine the weight of each indicators (4As) by multiplying with each aspect weight in Table 2. Based on the 4As, all indicators were explained in the questionnaire. Table 2 presents the weights of the 4As along with the experts' justifications.

(3) Table 3 shows that the indicators of energy consumption rate (0.28) and people's ability to independently provide energy (0.18) become, respectively, the first- and the second-highest indicators in the aspect of affordability.

Accessibility, as an indicator of the people's convenience of accessing energy, had the highest weight of 0.20, followed by an increase of the renewable energy supply with a weight of 0.18. The government's support to provide energy and ensure the availability of energy became the highest weight indicator in the aspect of availability, with a weight of 0.21 and 0.20. Meanwhile, with regard to acceptability, the highest weight indicator was the utilization of energy to positively impact the society and the environment, which scored 0.27, and the publicly accepted development of energy infrastructures, which scored 0.24.

(4) The results of questionnaire input for measuring energy security based on renewable natural resources in the eastern Sumba zone are calculated on average and multiplied by the results of the weight of each indicator. The average results are used to determine the weight of each aspect of energy security, while the scale used is 1 to 10, with details in Table 4.

(5) Calculating each security aspect (4As): From the calculation of the mean weight of each aspect (4As), the weights of affordability, accessibility, availability, and acceptability are, respectively, 5.37, 5.73, 5.99, and 6.39. In particular, this indicates that renewable energy in East Sumba is still considered low (5.91).

Table 1. Recapitulation of Respondent Assessment Result Data for Eckenrode Criterion Value

No.	Area of expertise	Institution	AFF	ACC	AVA	ACC
1	Accountancy	PLN (State Electricity Company)	3	4	1	2
2	Planning	PLN (State Electricity Company)	2	4	1	3
3	Mentor for rural community	Access Life Bali	1	4	2	3
4	Assistant credit marketing manager	Bank Rakyat Indonesia	1	3	4	2
5	Energy conversion	PLN	2	3	1	4
6	Assistant credit marketing manager	Bank Rakyat Indonesia	4	2	1	3
7	Power plant	PLN	3	4	1	2
8	Planning	East Sumba Regional Development Planning Agency	2	3	1	4
9	Government official	East Sumba Regional Development Planning Agency	1	3	4	2
10	Electrical engineering/lecturer	Kupang State Polytechnic	2	3	1	4
11	New, renewable energy/lecturer	Kupang State Polytechnic	2	3	1	4
12	New, renewable energy/lecturer	Kupang State Polytechnic	4	2	1	3
13	Electrical power engineering/ lecturer	University of Nusa Cendana	1	3	2	4
14	Solar power plant	Kupang State Polytechnic	1	3	2	4
15	Government official	East Sumba Regional Development Planning Agency	2	3	1	4
16	Travel business practitioner and public	Public figure	4	3	1	2
17	Government official	East Sumba Research and Development Units	4	2	1	3
18	Government official	Capital Investment Agency, one-stop integrated service	2	4	1	3
19	Government official	Capital Investment Agency, one-stop integrated service	2	4	3	1
20	Government official	East Sumba Regional Development Planning Agency	3	4	1	2
21	Government official	East Sumba Regional Development Planning Agency	3	4	1	2
22	New, renewable energy	Provincial Research and Development Units and Energy and Mineral Resources Agency	4	3	1	2
23	Secretary/policy	Research and Development	3	2	1	4
24	Government official	Provincial Research and Development Units and Energy and Mineral Resources Agency	3	4	2	1
25	Irrigation	Muria Sumba Manis	3	2	1	4
26	Renewable energy practitioner	USID-ICED II Program	2	3	1	4
27	Wind energy	MEAI	1	4	3	2
28	Electrical engineer	Hambapraing Solar Power Plant	3	2	1	4
29	Renewable energy practitioner from the private sector	PT Buana Energi Surya Persada	1	3	4	2
30	Business practitioner in the renewable energy sector	PT SESNA	3	2	1	4

Source:Processed by the Author

Table 2. Value of Each Aspect of Energy Security (4As)

Aspect	Assessment scale				Score	Weighted
	1	2	3	4		
Affordability	7	9	9	5	48	0.267
Accessibility	0	7	13	10	27	0.150
Availability	21	4	2	3	73	0.406
Acceptability	2	10	6	12	32	0.178
	3	2	1	0	180	1

Source: Processed by the Author

Table 3. Weight of Each Security Indicator Based on the 4As

Aspect	Indicator	Weight/aspect	Final Weight
Affordability	Energy utilization efficiency	0.15	0.039
	People's ability to independently provide energy	0.18	0.049
	Energy consumption rate	0.28	0.073
	Ability to meet the standard of energy consumption per capita	0.15	0.040
	Ability to adjust the energy supply to the population's growth	0.12	0.031
	Ability to adjust the energy supply to the potential of growth in income per capita	0.13	0.034
		1.00	0.267
Accessibility	Increase of renewable energy supply	0.18	0.028
	Energy supply quality improvement	0.10	0.015
	Capacity of renewable energy distribution	0.14	0.022
	Convenient access to energy	0.20	0.030
	Infrastructure that supports accessibility	0.17	0.025
	Strategic energy reserve	0.08	0.011
	Distance to the energy sources	0.13	0.020
		1.00	0.150
Availability	Increase in renewable energy	0.14	0.056
	Contribution of energy import reduction	0.03	0.014
	Energy diversification index (diversification of potential energy resources)	0.10	0.040
	Energy continuity assurance	0.20	0.083
	Availability of electrical power plant technology	0.16	0.067
	Support from government policy for energy availability	0.21	0.086
	Support from private sector's investment for energy availability	0.15	0.061
		1.00	0.406
Acceptability	Utilization of renewable energy that can reduce greenhouse gas emissions	0.09	0.016
	Development of energy infrastructures that are publicly accepted	0.24	0.043
	Energy utilization that can bring about positive impacts on the society and environment	0.28	0.049
	Public readiness for accepting renewable energy	0.23	0.040
	Environmental carrying capacity	0.12	0.022
	Accomplishment of an ideal energy mix	0.04	0.007
		1.00	0.178

Source: Processed by the Author

Table 4. Mean Values of Renewable Energy Security Indicators in East Sumba

Aspect	Indicator	Indicator's mean value	Aspect's mean value
Affordability	Energy utilization efficiency	5.83	5.37
	People's ability to independently provide energy	4.31	
	Energy consumption rate	5.38	
	Ability to meet the standard of energy consumption per capita	5.14	
	Ability to meet energy demand as the population grows	5.76	
	Ability to meet energy demand as the income per capita rises	5.83	
Accessibility	Increase of renewable energy supply	5.66	5.73
	Energy supply quality improvement	5.90	
	Capacity of renewable energy distribution	5.52	
	Convenient access to energy	5.31	
	Infrastructure that supports accessibility	4.97	
	Strategic energy reserve	6.41	
	Distance to energy sources	6.34	
Availability	Increase in renewable energy	5.73	5.99
	Contribution of energy import reduction	5.07	
	Energy diversification index (diversification of potential energy resources)	6.00	
	Energy continuity assurance	6.27	
	Availability of electrical power plant technology	6.30	
	Support from government policy for energy availability	6.60	
	Support from private sector's investment for energy availability	5.93	
Acceptability	Utilization of renewable energy that can reduce greenhouse gas emissions	6.23	6.39
	Development of energy infrastructures that are publicly accepted	6.43	
	Energy utilization that can bring about positive impacts on the society and environment	6.80	
	Public readiness for accepting renewable energy	6.27	
	Environmental carrying capacity	6.83	
	Accomplishment of an ideal energy mix	5.77	

Scale information (1–10): low (0 to <6), moderate (6 to <7), good (7 to <8), and high (8–10).

Source: Processed by the Author

Table 5. Calculation of the Energy Security Index in East Sumba

No.	Criteria	Value	Mean value	Index value	Aspect value	Aspect value (%)
1	Energy utilization efficiency	0.039	5.83	0.228		
2	People's ability to independently provide energy	0.049	4.31	0.212		
3	Energy consumption rate	0.073	5.38	0.395		
4	Ability to meet the standard of energy consumption per capita	0.040	5.14	0.204		
5	Ability to meet the energy demand as the population grows	0.031	5.76	0.177		
6	Ability to meet the energy demand as the income per capita rises	0.034	5.83	0.200	1.417	14.2%
7	Increase of renewable energy supply	0.028	5.66	0.156		
8	Energy supply quality improvement	0.015	5.90	0.087		
9	Capacity of renewable energy distribution	0.022	5.52	0.120		
10	Convenient access to energy	0.030	5.31	0.157		
11	Infrastructure that supports accessibility	0.025	4.97	0.124		
12	Strategic energy reserve	0.011	6.41	0.073		
13	Distance to energy sources	0.020	6.34	0.127	0.844	8.4%
14	Increase in renewable energy	0.056	5.73	0.319		
15	Contribution of energy import reduction	0.014	5.07	0.069		
16	Energy diversification index (diversification of potential energy resources)	0.040	6.00	0.237		
17	Energy continuity assurance	0.083	6.27	0.520		
18	Availability of electrical power plant technology	0.067	6.30	0.420		
19	Support from government policy for energy availability	0.086	6.60	0.569		
20	Support from private sector's investment for energy availability	0.061	5.93	0.361	2.496	25.0%
21	Utilization of renewable energy that can reduce greenhouse gas emissions	0.016	6.23	0.102		
22	Development of energy infrastructures that are publicly accepted	0.043	6.43	0.273		
23	Energy utilization that can bring about positive impacts on the society and environment	0.049	6.80	0.336		
24	Public readiness for accepting renewable energy	0.040	6.27	0.251		
25	Environmental carrying capacity	0.022	6.83	0.151		
26	Accomplishment of an ideal energy mix	0.007	5.77	0.042	1.156	11.6%
	Value	1.000	5.87	5.912		59.1%

Source: Processed by the Author

(6) Calculating the energy security index of East Sumba: The former calculations show that natural-renewable energy security in East Sumba is still low (5.91). The aspect of availability had the highest energy security index value (2.496), which is still low because the energy resources have not been optimally utilized. Affordability scored an index value of 1.417, which is considered low as well. This is likely a result of poverty in East Sumba, which makes energy unaffordable. Meanwhile, acceptability (1.156) was low as well. The index value of accessibility was the lowest among all aspects (0.844) because only people who reside closer to the road network could access energy, but the topography of East Sumba is hilly and includes grasslands with decentralized settlements in Table 5.

The availability of natural-resource-based energy in East Sumba is considerably high because of the various potential resources, such as sunlight, water, biomass, wind, and biogas. However, the energy security index in East Sumba is still considered low owing to several factors, such as the low affordability, triggered by poverty in Table 6. Moreover, accessibility to energy in East Sumba is challenging because the topography of East Sumba is hilly and includes grasslands with decentralized settlements, covering a vast territory. In addition, support infrastructures such as roads negatively affect the low index of energy security. The lack of an institutional model also discourages investors from investing in East Sumba. This notion is in agreement with what the State Electricity Company stated; that is, the electrification ratio in East Sumba is still low (31%).

Table 6. Energy Security Aspect Index

Energy security aspects	Index	Description
Availability	2.496	This is because energy resources have not been optimally utilized.
Affordability	1.417	This is because people in East Sumba live in poverty.
Acceptability	1.156	People need energy, but they are not aware of the potential energy resources around them.
Accessibility	0.844	This is because energy can only be accessed by people who live around road infrastructures, whereas the topography of East Sumba is hilly and includes grasslands with decentralized settlements.
Energy security in East Sumba	5.912 (59.1%)	Low: the energy security index in East Sumba is particularly low.

Source: Processed by the Author

These energy issues in the island of Sumba can be addressed through Presidential Regulation No. 5 of 2006, which states that, in 2025, the energy mix from renewable energy is expected to reach 15% of the total national energy demand, which is consistent with the Energy and Mineral Resources Minister's Regulation No. 3015/2015, which states that 100% of the energy in the island of Sumba will be supplied by renewable resources in 2020 (Lowi, 2016). The island has a high potential for new, renewable energy resources. The micro hydro power plant capacity in the island of Sumba is 15 MW, whereas the wind power plant capacity is even larger, 168 MW. Solar radiation amounts to 5 kWh/m2 per day, which is sufficient to satisfy the energy requirements in Figure 1. According to the State Electricity Company, the electrical power demand in the island in October 2014 was 10.7 MW, whereas the current electrical power supply is almost 15 MW, with only 20.2% supplied by new, renewable resources (DB-DJEBTKE, 2015).

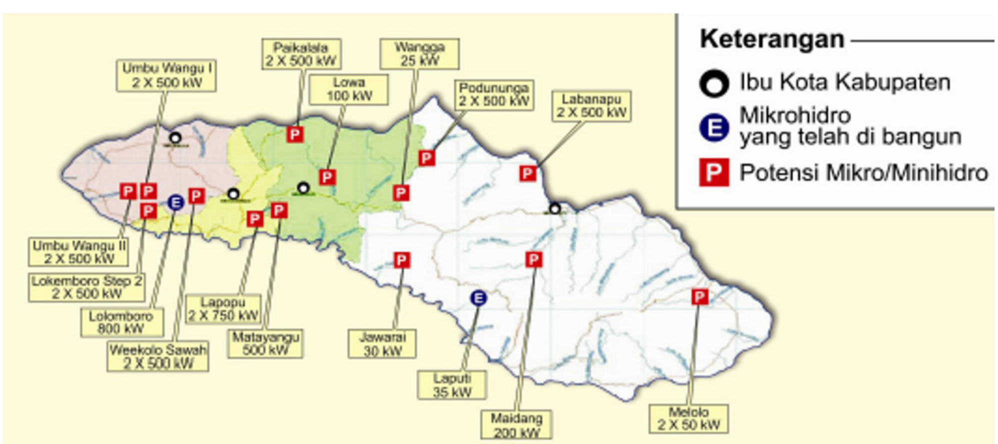

Figure 1. Mini Hydro Potential Mapping
Source: DJEBTKE, 2012

Accessibility to energy resources is, however, still limited. The electrification ratio was 24.5% in 2010 and 29.3% in 2013, with per capita electricity consumption of only 42 kWh, whereas the per capita national consumption was 591 kWh. This was a result of the inadequate energy infrastructure and low consumption rate (Sumba Iconic Island, 2012).

The government-led Directorate General of New, Renewable and Energy Conservation (Direktorat Jenderal Energi Baru Terbarukan dan Konservasi Energi, DJEBTKE) of the Ministry of Energy and Mineral Resource has made efforts to make Sumba an "Iconic Island." The implementation of the "Iconic Island" program followed by multi-actor (government, the private sector, NGOs, and the society) and multi-funding (national budget, the private sector, international grants, and the society) approaches. Both approaches motivated all stakeholders in the renewable energy sector to contribute to its development in Sumba. Since initiated in 2011, capacity of renewable energy has reach 5.87 MW renewable energy with a composition of 70.3% from micro and mini hydro power, 27.9% from solar power, 1% from wind power, 0.62% from biomass power, and the rest (0.2%) from wind–solar hybrid power plants (DB-DJEBTKE, 2015).

Table 7. Sumba's Iconic Island Program Achievement

Installation	Realization 2011	Realization 2012	Realization 2013	Realization 2014	Accumulated realization 2011–2014
Micro and mini hydro power plants	2 units (52 kW)	5 units (1,505 kW)	3 units (1,632 kWp)	2 units (232 kW)	12 units (342 kW)
Centralized solar power plants	11 units (43 kWp)	14 units (607 kWp)	8 units (45 kWp)	6 units (216.9 kWp)	39 units (911.9 kWp)
Decentralized solar power plants	90 units (3.1 kWp)	11,054 units (328.80 kWp)	3,221 units (87.79 kWp)	464 units (19.35 kWp)	14,829 units (439.1 kWp)
Solar water pumping	N/A	2 units (5.16 kWp)	1 unit (1.44 kWp)	N/A	3 units (6.6 kWp)
Wind power plants	N/A	N/A	95 units (47.5 kW)	5 units (2.5 kW)	100 units (50 kW)
Biomass power plants	N/A	N/A	1 unit (30 kW)	N/A	1 unit (30 kW)
Biogas digesters	61 units (360 m3)	221 units (1,606 m3)	526 units (4,088 m3)	220 units (1,412 m3)	1,173 units (7,946 m3)
Energy-saving stoves	N/A	1,600 units	375 units	125 units	2,100 units
Distribution networks	N/A	N/A	45.41 km (JTM) 72.88 km (JTR)	11.46 km (JTM) 31.05 km (JTR)	56.87 km (JTM) 104.93 km (JTR)
Cumulative installed capacity (kW)	96.1	2,446.02	1,853.73	470.77	4,868.62

Notes:
JTM : medium voltage electricity network
JTR : low voltage electricity network

Source: Directorate of Bioenergy of Directorate General of New Renewable Energy and Energy Conservation, 2015

DJEBTKEalso supported the "Iconic Island" program up to 2014 by building new, renewable energy infrastructures in Table 7. Energy was generated from several installations, such as a micro and mini hydro power plant with a 32 kW capacity, six centralized solar power plants, 464 decentralized solar power plants, 5 wind power plants, 1 biomass power plant with a 30 kW capacity, 220 biogas digesters, and 2,200 energy-saving stoves granted to the people of Sumba (DB-DJEBTKE, 2015).

The ratio of electrification in the island of Sumba in 2015 was 45.60%, of which 10.42% was contributed by new, renewable energy. At the same time, the electrification ratio in East Sumba was 49.87%, that in Central Sumba and West Sumba was 38.38%, and that in Southwest Sumba was 43.89%. The cumulative installed capacity of new, renewable energy in the island from 2011 to 2015 was 5,929.04 kW with a composition of 4,437 kW (74.84%) from micro and mini hydro power plants, 870.4 kW (14.68%) from centralized solar power plants, 553.54 kW (9.00%) from decentralized solar power plants, and the rest (88.1 kW, 14.68%) from solar water pumping, wind power plants, and biomass power plants. According to the roadmap marked for the island of Sumba as a Renewable Energy Iconic Island, in 2020, the demand for electricity in the island will be 62.9 MW, and it is expected that 43,381 MW will be supplied from new, renewable energy, whereas 19,518 MW will be from diesel power plants/gas engines in Figure 2. Therefore, in order to satisfy the electrification ratio target of 95% in 2020 with 95% contribution from new, renewable energy, the island requires a power upgrade by as much as 50 MW, with 37.5 MW provided by new, renewable energy. Given that the electrification ratio in 2015 was 45.60%, the electrification ratio should be increased by 4.192% annually. Given that the installed capacity of power plants in the island currently reaches 17.53 MW (11.6 MW from diesel power plants and 5,928 MW from new, renewable energy), there will be a need for an additional power plant generating a minimum of 7.5 MW per year until 2020 (Lowi, 2016).

Figure 2. Sumba Island's Electricity Roadmap
Source: Lowi, 2016

According to a study by the Asian Development Bank (ADB), the island of Sumba has four new, renewable energy potentials: micro hydro, hydroelectric energy storage, wind power plants, and solar power plants. The ADB identified 300 potential locations to build low-cost microgrids to generate micro hydro power. These 300 locations were then filtered, selecting only 100 locations in close proximity to each other (approximately 1 km). The number of locations was further filtered to only 40 locations in 22 villages across the island. These locations were considered suitable because they had an adequate stream flow and were close to human settlements (Poek and Plaino, 2018).

The electrification ratio is defined as the number of electrified households divided by the total number of households. Table 8 shows the number of consumers, consumption, and consumption values of electricity from the State Electricity Company, listed according to subdistricts in 2016.

In five villages (Tawui, Lailunggi, Praimadita, Tandula Jangga, and Praiwitu) in East Sumba, people can now access clean electricity from solar photovoltaic or solar power plants in Table 9. Solar power plants, with a total capacity of 492 kWp, can supply 852 households and 57 public facilities with electricity, and 11 solar microgrids have been installed in these villages (MCA, 2018).

The energy security index of East Sumba is still particularly low. However, the potential for renewable energy is considerably higher, especially solar energy, hydroelectric power, and wind energy. This result is preliminary finding and, therefore, needs further action. It still needs to determine and assess the most sustainable and potential resource following the obtained criteria and indicators of the energy security index. From the selected prospective energy results, a grand strategy scenario will be constructed and studied for the development of the East Sumba zone energy security zone in the future. The strategy is to determine whether the development scenario in the future is optimistic, moderate, conservative, or even pessimistic.

Heyko, Hasid, and Priyagus (2016) presented one of the examples of choosing the best scenario of energy security. Oil fuel consumption in East Kalimantan is expected to reach 47,970.20 barrels by 2025; thus, conservative strategy (self-improvement) would be most appropriate with regard to renewable energy utilization. In addition, in the province of East Kalimantan, dispensing with fossil fuel use can be achieved by optimizing renewable energy such as biodiesel and biogas, which are more profitable than bioethanol. However, the most prospective resources in East Sumba are solar energy, hydroelectric power, and wind energy.

Table 8. Number of Consumers, Consumption, and Consumption Values of Electricity

No.	Subdistrict	Consumer	Consumption	Consumption value
1	Lewa	1421		1,818,880
2	Nggaha Ori Angu	313		400,640
3	Lewa Tidahu			
4	Katala Hamu Lingu			
5	Tabundung	373	142,849	477,440
6	Pinu Bahar			
7	Paberiwai	127	60,926	162,560
8	Karera	659	282,568	843,866
9	Matawai La Pawu	175	86,885	224,000
10	Kahaungu Eti	195	126,419	249,600
11	Mahu			
12	Ngadu Ngala	196	37,595	250,880
13	Pahunga Lodu	973		1,245,450
14	Wula Waijelu	455		587,400
15	Rindi	300		389,000
16	Umalulu	1893		2,423,040
17	Pandawai			
18	Kambata Mampabuhang			
19	Kota Waingapu	18730	32,476,156	23,974,400
20	Kambera			
21	Haharu	253		323,840
22	Kanatang			
	East Sumba	26063	33,213,366	33,370,996

Source: State Electricity Company, Sumba Branch, in BPS (2017)

From a case study in East Kalimantan, the development scenario must include the benefits, costs, opportunities, and risks (BOCR) and the appropriateness of the chosen method of renewable energy. The appropriateness of renewable energy development should be based on business properness, economic properness, technical properness, and willingness to pay. As stated by Wisena (2015), BOCR can take the form of "Benefits–Social–CSR," "Benefits–Environment–Physical," "Benefits–Technology–Technology Benefits," "Benefits–Economy–Stakeholders," "Cost–Technology–Technology Benefits," "Opportunities–Technology–Technology Benefits," and "Risk–Environment–Physical."

Energy security in East Sumba should satisfy market demands as well as global energy demands in the medium and the long-term, because global energy security faces several obstacles in the supply and demand, infrastructure, geopolitics, and environmental protection regulations. The energy security of China might get hampered in the next 20–30 years or more (Liu and Jiang, 2009). External factors reveal that maintaining a stable, sustainable, and affordable supply of crude oil is crucial. Although external conditions are crucial for China's energy security, domestic factors also need to be considered. With the supply of energy resources becoming the foundation of energy security, it is imperative to establish a robust domestic energy market system and energy management work frame. Besides, while petroleum safety is ensured, the supply of other energy products should be ensured as well, especially energy supply from coal, which is considered fundamental. In the present study, we analyzed useful global energy resources and whether global energy security and global economy can be maintained.

Furthermore, according to Kocaslan (2014), the energy security issues need to be reviewed using the concept of international energy security indicators, international energy security risk index, and international energy security rank, and we need to understand the summary of energy security of a nation. Score and rank bring about multidimensional effects on the trade agreement, investment, energy, and contract. However, the international energy security risk value and international energy security rank are responsible for improving the energy security. The energy security risk value itself is also an indicator of economic, political, social, and environmental risks; it reveals the issues in the respective sectors. Thus, improvements in the economic, political, social, and environmental sector will reflect on the energy security risk value, and vice versa.

Table 9. The number of electricity users according to the subdistrict (2012-2016)

No.	Subdistrict	2012	2013	2014	2015	2016
1	Lewa	929	1,015	1,198	1,324	1,421
2	Nggaha Ori Angu	167	182	194	201	313
3	Lewa Tidahu	—	—	—	—	—
4	Katala Hamu Lingu	—	—	—	—	—
5	Tabundung	290	301	313	336	373
6	Pinu Bahar	—	—	—	—	—
7	Paberiwai	88	92	95	98	127
8	Karera	250	265	281	307	659
9	Matawai La Pawu	108	112	120	128	175
10	Kahaungu Eti	151	154	157	165	195
11	Mahu					
12	Ngadu Ngala	226	227	231	241	196
13	Pahunga Lodu	754	762	776	796	973
14	Wula Waijelu	388	395	412	427	455
15	Rindi	242	248	255	272	300
16	Umalulu	1,530	1,610	1,684	1,758	1,983
17	Pandawai					
18	Kambata Mampabuhang					
19	Kota Waingapu	13,879	15,917	17,875	18,357	18,730
20	Kambera					
21	Haharu	189	192	198	218	253
22	Kanatang					
	East Sumba	19,191	21,472	23,789	24,628	26,063

Source: State Electricity Company, Sumba Branch, in BPS (2017)

Popescu (2015) conducted a research analyzing the economic component in energy security, which aims to verify the energy security concept from an economic and financial perspective. In this research, we suggest that energy sectors must be dynamic and active in order to reduce the gap between countries, mainly developing ones.

CONCLUSION

The study results showed that renewable energy security in East Sumba is particularly low (5.91). The aspect of availability scored the highest energy security index value (2.496). However, this index value is still considered low because the energy resources have not been optimally utilized. Affordability scored an index value of 1.417, which is also considered low. This is probably a result of the poverty in East Sumba, which renders energy unaffordable. Meanwhile, acceptability had a value of 1.156, still categorized as low. The index value of the aspect of accessibility was the lowest among all aspects, only 0.844, because of the poor access to the road infrastructure and the hilly topography of East Sumba that includes grasslands with decentralized settlements.

The availability of natural energy in East Sumba is considerably high, given the various potential resources, such as solar, water, biomass, wind, and biogas energy. However, the energy security index in East Sumba is still considered low because of several factors, such as low affordability, triggered by poverty. Accessibility to energy sources is also an issue because of the hilly topography of East Sumba, with grasslands with decentralized settlements, as well as the vast territory. In addition, supporting infrastructures such as roads also affect the low index of energy security. The lack of an institutional model also discourages investors from investing in East Sumba. These results are consistent with the information provided by the State Electricity Company, which stated that the electrification ratio in East Sumba is still low, only 31%.

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