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Improving Energy Security Model through Detailing Renewable and Energy Efficiency Indicators: A Concept for Manufacture Industry

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Abstract

Considering the depletion of fossil energy reserves, as an archipelago and developing country leading to industry, energy security plays an important role for Indonesia to ensure sustainable development. For the accurate long-term planning as well as tracking and following up, Indonesia's energy security needs to be reviewed and remodeled differently. The current study is aimed to improve the concept of Indonesia's energy security model through detailing clean energy indicators to support the development of renewable energy (RE) and energy efficiency (EE) programs, with a special focus on manufacture industry sector (industry). In this case, we will know in more detail the contribution of industry in RE or EE, or regional provinces and islands, to see the RE and EE road map to the issues and actions to be taken. For that, there are three important steps must be completed for this study. First, to answer the preliminary concerns, such as; Why is this energy security model more focused on RE and EE? How important are RE and EE policies for Indonesia's development? What indicators should be used, especially for accuracy to 2025 and 2050? Second, to detail RE and EE indicators into sub-categories and provincial locations in Indonesia. Third, to describe how to connect the improvement detailed indicators into the existing or improvement model of ES, which mainly categorized; availability, affordability, efficiency, sustainability, and governance. As a result, the potential of RE and EE will be more clear, which can be broken down into 34 sub-sectors of industry within 34 provinces or possibly up to 514 cities/districts of Indonesia. From local/central government level, this study can contribute as a tool to evaluate performance by using key energy performance indicator (KEPIs), as a control to monitor energy issues, as a clearer guidance to develop the comprehensive energy policies for the long-term planning for energy security; as simulation tools to test some ideas or suggestion before policies to be taken related to industry.

Keywords: *energy security, renewable energy, energy efficiency, energy model, energy indicator, industry*

INTRODUCTION

Energy is the key component to ensure the development of all countries, included Indonesia. Disruption of energy supply, both internally and externally, will directly affect the economic growth and development. To secure the national development, it is required an energy independence that leads to energy security. In general, energy security is defined as conditions that ensure the availability of energy, and public access to energy at affordable prices in the long term and, not affected by regional or international issues. The question now; how is the energy security condition in Indonesia? Based on the latest data released by British Petroleum (BP) [1], since 1998, an increase of energy consumption, either oil, natural gas, coal, and electricity by 3.2%, 2.0%, 13.4%, and 7% year respectively. It should be noted, in fact Indonesia is not a rich country in fossil energy reserves. The reserves of oil, natural gas, and coal have only 1%, 3%, and 3.6% of world reserves, respectively. Details, oil reserves consist of 3.7 billion barrels with production of about 332 million barrels/year, only enough for 12 years. Natural gas reserves of about 2.9 TCM (trillion cubic meters) and consume 0.07 TCM/year, then this is only sufficient for 41.6 years. In addition, the coal resources of 28 billion tones with a production of about 0.421 per year per year, then this is only enough for about 67 years.

In the final energy consumption as shown in Fig.1, the industry sector is the biggest consumer, which is 38%, with a share of 40% coal, 23% oil, 28% of gas, and electricity by 9%. Followed by

the transportation sector, which accounted for 35% of final energy consumption, which is almost 99, 65% depend to oil, the remaining electricity of 0.015%, and 0.03% of gas.

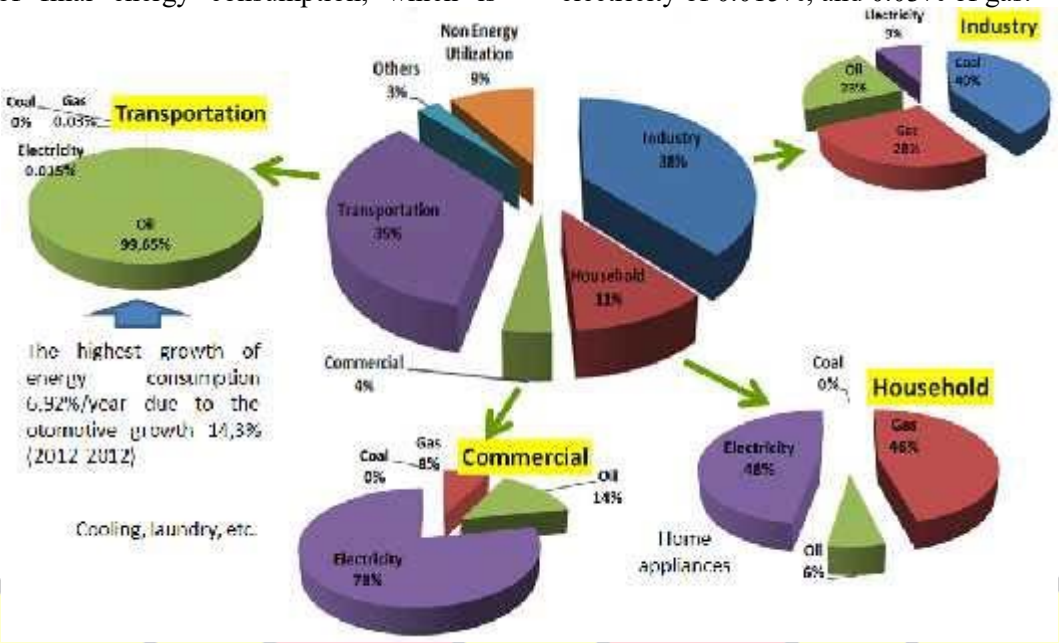

Figure 1. Final energy consumption by sector in 2013 (excluded traditional biomass)

Meanwhile, almost 95% of the electrical energy source is currently generated by burning the fossil fuels, mostly coal and gas. Currently, the electrification ratio is about 80% (20% no electricity, especially in remote areas and outer islands). Electric energy demand growth rate is 7% per year, which is not matched by the supply growth, resulting frequent blackouts in several cities in outside Java. Admittedly, the number of Indonesian population of about 248.8 million people, with the population growth of 1.49%, and the yearly economic growth of 7% [2], have contributed to the increased of energy consumption [3]. However, it should be noted that the high dominance of fossil energy in the primary energy mix, 97%, compared with only 3% of renewable energy (RE). The potential of RE is huge, that is: micro-hydro 0.77 GW, geothermal 16,5 GW, biomass 0.18 GW, solar 4.8 kWh/m^2.day, and wind 3-6 m/s [4].

Actually, in 2006, the Government has issued the Presidential Decree No.05/2006, on a target of 17% energy mix from RE, with the details, as follows: 33% of coal, 30% of natural gas, 20% of oil, the remaining 17 % of RE, which is; geothermal, hydro, solar, wind, biomass/biofuels, hopely energy investments amounted to USD 13.197 million [5]. As a reference, the status of primary energy consumption in 2006 [1], 24% of coal, 31% of natural gas, 43% of oil, and the remaining 2% of RE. Apparently, the realization of the primary consumption in 2013 is still far from the target, which is 32% of coal, 21% of natural gas, 44% of oil, and the remaining 3% RE [1]. That is, after 7 years, no fundamental changes as a result of energy policies that have been issued previously. Finally, in 2014, the government made revisions by issuing a new national energy policy, Government Regulation (PP) No.79/2014, which corrects the target energy mix in 2025 and also in preparation for 2050, with details; 25% of coal, 22% for natural of gas, 24% of oil and 31% of new and RE [6]. However, as predicted by 2050 [7], the RE only could reach 13.7% (for low scenario), or 14.9% (for high scenarios). Energy demand of industrial sector, which is considered as the national economy driver, is expected to increase and dominate the total final energy demand followed by transportation sector which supports the economic activity. In both scenarios, share of energy demand in industrial sector will increase from 45% in 2014 to 49% in 2050.

While in transportation sector, energy demand will increase from 36% in 2014 to 39% for base scenario and 40% for high scenario in 2050.

Based on what has been discussed above, the general condition of Indonesia's energy as follows; High energy demand has not been matched due to lack of supply, distribution, and access, Fossil energy reserves declined very rapidly due to consumption and export, There are still subsidized energy prices, which affect the poor energy conservation, Utilization of RE is not optimal, unsupported by the capacity of R&D and energy industry. Indonesia should maintain the commitment on the issue of climate change. Conclusion, Indonesia's energy security is quite vulnerable and weak [8] in facing energy trilemma [9]. Even though there have been several actions and programs based on energy policies and regulatory frameworks, include; diversification, substitution, technology development, and sustainability, which generally cooperate with friendly countries, companies and international organizations.

OVERVIEW, DEFINITION AND MODEL

Energy security is a fairly active area of research in recent years, discussed range from concept of definition, framework methodology to determine the dimensions, the indicators used by certain techniques (surveys, interviews, etc), and the development of the composite index, as well as assessment evaluation for comparision by single or grouped countries. It can be seen from various review papers, such as the discussion of "typology of energy and security" [10], "definition, dimension, and indexes" [11], "perspective to integrate the disciplines root of politics, science and engineering, and economics" [12], and "commonly used methodology and approach" [13][14]. Due to ambiguous and allows for multiple interpretations, the existence of highly multidisciplinary topics within energy security, suggested to be categorized into four perspectives: geopolitical, economic, policy related, and technological, with diversification strategy is very important for ensuring energy security over the entire supply process [15]. So far, there is no clear and unequivocal agreement on the definition of energy security, but shortly, International Energy Agency (IEA) defined that energy security as "the uninterrupted availability of energy sources at an affordable price" [16]. Previously, the concept of energy security of a country is to secure access to fossil energy sources, such as oil [17]. To answer the challenging complex energy security, the increasing need for energy while depleting reserves of world oil, and increasing pressure on global climate change, the issues extend to such as; price volatility, supply chain, political stability of oil-producing region, environmental sustainability, RE, EE, and so on, various models have been offered by applying certain methods and techniques involving various indicators, simplified into a composite index.

In fact, the discussion of energy security cannot be separated from the topic of energy models. Models are convenient tools where performing tests or experiments in the real world are impractical, too expensive or out-rightly impossible. Energy security models, like other models, are simplified representations of real systems. They vary, ranging from the simple to the complex or from the most important to the less important, depending on the type and number of indicators used.

In other words, the complexity of today's energy security issues, can no longer be anticipated with simple and common indicators, but might include the complex indicators, focus on the priority and objectivity as well. Ideally, designing energy security of a nation must be adapted to the specific context in a country, such as; special condition, level of economic development, risk perception, as well as the strength of the energy system and geopolitical issues [18]. The opportunities for improvement to energy security is still wide open, because there is still a gap and freedom to a specific indicator [11]. That is, from the fossil oriented to the development of RE and EE, with a focus on specific sectors (residential, commercial, industrial), and certain regional (rural/urban, Java/non-Java such as Sumatera, Borneo, Celebes, the Moluccas, Papua, etc.). In essence, how Indonesia improve the internal capabilities on energy supply by reducing dependence to the other countries. In fact, a scientific assessment of

energy security in Indonesia was published in 2005 [19]. So, to get an accurate prediction, Indonesian energy security models need to be developed properly. This is the real challenge and also opportunity.

In general, the existing models merely the result of calculation, tend to be as predictive analysis without giving an overview and detailed solutions about what to do, especially for specify country. From the search results of scientific papers that discuss related to Indonesia, both regional and national, none of which specifically provides more detailed analysis of the RE and EE. As a developing and archipelago country, which is divided into several regions, with many rural areas in the borders do not have good access to energy, so the development of an energy security like Indonesia needs to be modeled differently [20]. The model should be used as accurate long-term planning, as well as tracking, and following up (actual vs. projected). As an initial step, the purpose of this study is to discuss how to improve the concept of Indonesia's energy security model with techniques detailing clean energy indicators, focus on manufacturing industry sector that support the development of RE and EE programs. This model will propose key energy performance indicators (KEPI) by utilizing more detailed notation indicators for RE and EE, as well as other indicators such as the gross domestic product (GDP), and so on. In this case, we will know in more detail the contribution of RE or EE, especially industry, or in an area or island to another indicator of GDP, so it is clearer to see the RE and EE road map and the issues and actions will be taken.

METHODOLOGY

To achieve the purpose of the study mentioned above, there are three important concepts must be completed.

The first, to answer the preliminary concerns: The problem discussed in this study is how to detail the clean energy indicators through the utilization and growth of RE and EE as an early stage in improving the concept of Indonesia's energy security model, which certainly supports the development of RE and EE programs. The following questions should be answered in this study, namely: Why is this energy security model more focused on RE and EE? How important are RE and EE policies for Indonesia's development? What indicators should be used, especially for accuracy to 2025 and 2050?

The second, to explain the main important part of this study is how to make a more detailed indicator of the RE and EE? Here, the o*bjectivity to select the the indicator is very crucial.* Selection of indicators for a given dimension has the effect of evaluation results, so with some decision-making criteria to be more objective [21][22]. Certain dimensions or indicators may have different degrees of importance. From a stakeholder perspective, it may have a significant effect on the performance score. For long-term and strategic analysis, data resolution in combining models will likely be less detailed in conducting operational analysis. This requires a subjective model of stakeholders. The RE and EE indicators should reinforce each other in a unity of national and world goals for clean energy, as stated in the Sustainable Development Goals (SDGs) [23].

Then, the third, to describe how to connect the improvement detailed indicator into the existing or improvement model of energy indicators. In assessing energy security, the dimensions and indicators used should be able to pursue national energy targets against; energy availability, energy development priorities, national energy use, national energy reserves, diversification and conservation, environmental and safety issues, price and incentive subsidies, infrastructure, energy and industry, research and development, local and regional distribution, technological development status, (community and demand), and financing institutions. This will only be achieved with detailed indicators, involving all sectors (such as residential, commercial, transportation, and industry), regional proportional distribution, based on the realization of RE and EE.

RESULT AND DISCUSSION

Preliminary Concerns

The following are the answers to the questions raised in the previous section. Let's

start on the first question.*Why is the energy security of this concept model focused more to RE and EE?* If the paradigm of high dependence on fossil energy has not been shifted, both for consumption and export do not expect many RE and EE activities will receive serious attentions. As a result, there was poor development of RE by the reason of limited investment and research, while EE has not been entrenched nationally. To increase both production and proven reserves are a necessity, but to reduce the percentage contribution of fossil energy in the national energy mix is also a top priority. In addition, the contribution of RE in the national energy mix should be encouraged [24]. Hopefully, the model will further accelerate the RE and EE development in Indonesia, of course with the transition from oil [25] to coal, or natural gas [26]. RE and EE are the twin pillars and the foundation of a sustainable energy policy, which can play an important role in mitigating energy security risks and emission issues.

The next question: *How important is the RE policy for the development of Indonesia?* The deployment of RE policy is very important for the development of Indonesia. At least, there are two real contributions from RE projects. First, to increase the diversity of energy sources such as electricity, through local generation, contributes to the security, flexibility and resilience of energy systems. Second, to increase the income per capita, as the increase of RE consumption per capita. Across time, RE consumption percapita in emerging economies is expected to grow faster than real percapita income [27]. Both contributions only can be achieved by designing an effective RE policy with a good understanding of energy system and RE income characteristic.

The next question *How important is the EE policy for the development of Indonesia?* The deployment of EE policy is also very important for the development of Indonesia. At least, there are two real contributions from EE programs. First, improving EE policy is relatively preferable to limit the energy consumption policy, which increases the income of the majority of households. Second, the facts, implementation EE technologies programs in developing countries, has shown quite favorable investment [28]. Actually, some EE policies have been implemented since 2006, but the results are very small. As one of the highest energy intensity country in the world, the EE policy has not harmed the economic growth, Indonesia should re-introduce the EE policy [29].

The last question *What indicators should be used, especially for the accuracy toward 2025 and 2050?* Energy security is difficult to measure using too simple or too complex indicators. Actually, from what we have discussed previously, Indonesia's energy policy has focused primarily on the simple availability dimension (reflects to Presidential decree No.5/2006 and 30/2007), which the self-sufficiency and diversification of fossil energy are the main priorities. Indonesia should be more focus to the other dimensions, such as; affordability (energy prices & subsidiy), efficiency, aceptability, socio-effect, environment, governance, and so on.

Notation and expression of Detail Indicators

Now, the question is, how to make a more detailed indicator of the RE and EE? According to original concept of this study, generally for RE and EE, both are made in more detail with notation based, such as; The sector (residential = R, commercial = C, transport = T, industry = I, and area (Java = J, from outside Java = OJ, split to Sumatera island (OJS), Borneo (OJB), Celebes (OJC), Maluku OJM), Papua (OJP), etc. Then, specifically for RE, it can be subdivided into: non-Solar (NS) and Solar (S), which can be separated for Thermal (T), Electricity (E), and The indicator depicting RE in the industrial sector has a notation of IRE, or more detail for the solar thermal on the island of Sumatera (outside Java) has notation OJSTIRE, as well as RE notation also applied to EE, which can be divided into: Process = P, Utility = U, Machine = M. Thus, energy efficiency efforts in the process for cooling in industries, located on the island of Java have a notation; JCPIEE. A full description of the concept of the details of RE and EE indicators. Due to the current focus on the industrial sector, the following Figure 2 (constructed from ref.[2][30]) explains the detailing concept for the industry.

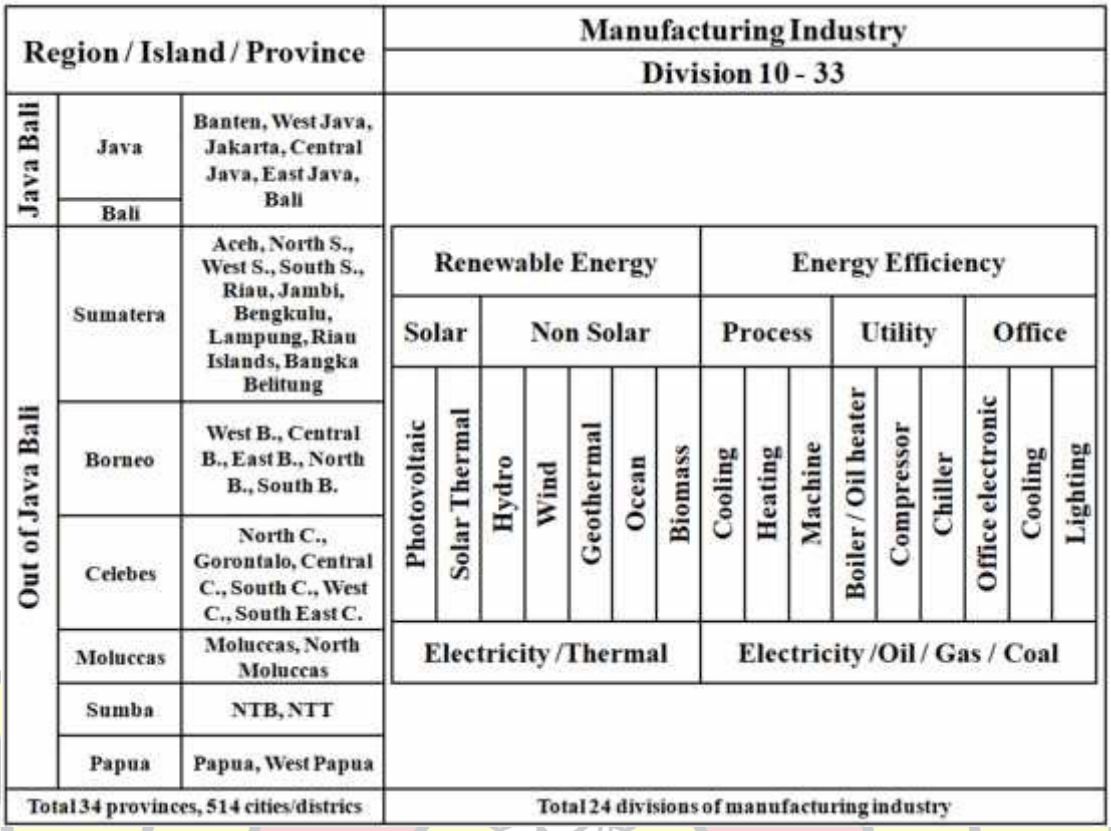

Figure 2. Concept of the detailing RE and EE in industry

Referring to ref.[31], the RE indicator is inclusively in the dimension of availability, while the EE in the dimension of technology development and efficiency. Indonesia's energy security (ES), for all provinces and sectors, can be expressed simply by:

$$ES = f\left(Av + Ef + Af + Su + Go\right) \quad (1)$$

where, Av, Ef, Af, Su, and Go are the main indicators of Availability, Efficiency, Affordability, Sustainablity, and Governance, respectively. The main indicator Av is a function of fossil energy FE and energy efficiency EE, which is expressed by:

$$Av = f\left(FE + RE\right) \quad (2)$$

an energy user, industry must also be responsible for availability to produce energy from renewable energy, then RE can be expressed by;

$$RE_{ind} = f\left(S + NS\right)\right) \quad (3)$$

where, S and NS are Solar and Non-solar, respectively. At this stage, S and NS only for the purpose of simplifying it, without neglecting the role of other renewable energy sources, which of course can still be developed in more detail at the next research stage. Then, the energy efficiency (EE) in industry also can be expressed as:

$$EE_{ind} = f\left(\mathrm{P}+U+O\right) \quad (3)$$

where, P, U, O are; process, utility, and office, respectively, as explained previously. Since

The current role of *FE* 76,8% [7] should be reduced with more results of RE and EE. As process and utility are the largest energy users in the industry, focus should be more given, regardless of the energy savings opportunities in the office.

Based on the presentation of the Director of Energy Conservation, on September 15, 2017 in IndoEBTKE ConEx 2017 [32], there are 244 companies identified for compulsory implement energy management and report its energy consumption as stipulated in Government Regulation (PP) No. 70/2009 [33]. These companies which consump about 6.000 TOE or more each are mostly in various type of industries and only 1 company engaged in construction building, as shown in Table 1.

Table 1. Identified companies for energy management [32]

No.	Manufacture Industry Division	Companies
1	Textile industry	40
2	Iron & steel industry	34
3	Manufacturing industry	30
4	Pulp & paper industry	20
5	Power plant industry	20
6	Agro industry	13
7	Chemical industry	11
8	Petrochemical industry	11
9	Food industry	11
10	Beverage industry	4
11	Fertilizer industry	8
12	Cement industry	8
13	Motor vehicle industry	8
14	Coal & minerals mining industry	8
15	Oil & gas industry	10
16	Other industries (cigarettes, etc.)	7
17	Construction building industry	1
Total Companies		**244**

In addition, the ref.[32] also describes the distribution of 11 provinces which are the largest energy users, with a consumption of about 91% of national energy consumption, as shown in Table 2. They are targeted for government compaigns to cut energy use by 10%. From the table, there is an additional consumption of 3.1% from 2014 to 2015.

At this time, further data is needed to detail what type of industry is operating in the 11 provinces, in order to obtain the indicator as illustrated in Fig.2. As for the long term, the data collection should be continued not limited only to industries with high energy consumption. It is expected to all 34 sub sectors of the industry are well recorded [30]. The scope is expected to be extended to all cities/districts, totaling 514 throughout Indonesia [2].

Tabel 2. Targeted Provinces for 10% Energy Consumption Cutting [32]

No.	Province	Consumption in GWh/Year	
		2014	**2015**
1	Banten	51.277	51.257
2	Jawa Barat		
3	DKI Jakarta & Tangerang	41.269	41.328
4	Jawa Timur	30.523	30.824
5	Jawa Tengah	19.631	22.892
6	Sumatera Utara	8.271	8.703
7	Sumatera Selatan	6.199	6.606
8	Sulawesi Selatan	5.247	5.441
9	Bali	4.335	4.594
10	Riau	3.971	4.241
11	Lampung	3.392	3.570
Total		**174.115**	**179.456**

With more detailed notation indicators for RE and EE, it is expected later to be used as one of the key energy performance indicators (KEPI), to complement other pre-existing indicators. In this case, we will know in detail the contribution of RE or EE in each sector, especially industry, or in other regions or islands. so it is clearer to see the RE and EE roadmaps and the issues and actions to be taken.

The Next Steps

As shown in Table 3, the current research is a preliminary step in designing an energy security monitoring system for Indonesia, which is planned to be located in our university. It is hoped that the next step is to make improvements to the current energy security model with existing RE and EE detailing concepts, involving specialists in the fields of RE/EE, policy, economic and environment. Here, the modeling will be done by improving the simple expression of Eq.1-4, which has already been discussed. The purpose to involve various specialists is to get a complete analysis, so hopefully the result is more accurate. The next steps are data simulation, data processing, and monitoring/perpetuation, with involving the additional IT specialist.

Table 3. The steps of completed research

Phase	The Steps	Specialist Involved				
		RE & EE	Policy	Economic	Environment	IT
1	Concept Detailing of RE and EE	•	•			
2	Improvement Model (included rules of the game)	•	•	•	•	
3	Simulation (valid data) & Comp. idex	•	•	•	•	•
4	Data Processing (incl.dashboard)	•	•	•	•	•
5	Monitoring and Perpetuation	•	•	•	•	•

CONCLUSION

Based on what has been discussed, to ensure energy security, Indonesia should be more serious and focused in the development of renewable energy and energy efficiency. The concept of detailing RE and EE, to improved the the current energy security model, is in line with the efforts to strengthen the energy security. The industrial sector, as the largest sector in consuming energy, should be given special attention, especially for some industry categories in several provinces in Indonesia. To pursue that, these detailed indicators can be used as a tool for evaluating performance for each sector and local government.

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