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Determining Factors of Energy Intensity in The Manufacturing Industry of Provinces in Indonesia

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Abstract

Energy is vital to Indonesia's economic activities in various sectors. Energy plays an important role in the sustainability of the economic structure, which includes is the manufacturing industry. However, limited natural resources are one of the challenges for policymakers. Although energy conservation policies have been implemented in Indonesia since 1982, their enforcement in the manufacturing industry sector has not been solutive in supporting the development of the manufacturing industry in all regions. This study aims to determine the relationship between the development of energy intensity and economic growth in 26 provinces of Indonesia, using the growth and share analysis method from the data the authors have obtained. The results showed that the paper and printed goods, cement, and non-metallic minerals industries are the sub-sectors with high energy consumption. Then, Riau, DKI Jakarta, and West Java provinces are in the dominant quadrant for economic growth, but their energy intensity is in the low/slow quadrant. This indicates that industries in these three provinces have efficient use of energy.

INTRODUCTION

Energy plays a crucial role in various sectors of economic activities in Indonesia, both in the production and consumption side. This is reflected in a 2019 data published by the National Energy Council's Secretariat, which recorded Indonesia's total energy consumption at 114 million tonnes of oil equivalent (MTOE) in 2018. With its limited nature, energy should be utilized as efficiently as possible, especially for the good of the people. From the input side, Indonesia is rich in both renewable and non-renewable energy resources. However, exploration in the country is still centered on fossil, non-renewable energy resources, such as crude oil, gas, and coal (Figure 1).

The use of natural resources is key to a significant contribution towards economic growth. However, its limited availability has challenged practitioners and policymakers in allocating the resources. Especially, the issues of global warming and pollution have been stirring debates among the energy, resources, and economic sector. International Energy Agency (2019) reported that Indonesia's economic growth is parallel to its growth in energy consumption between 1990 and 2018. Energy consumption in Indonesia saw an average annual increase of 4.99%, whereas average growth was recorded at 5.03% annually. The increase in energy use, meanwhile, was dominated by the electricity, industry, and transportation sector.

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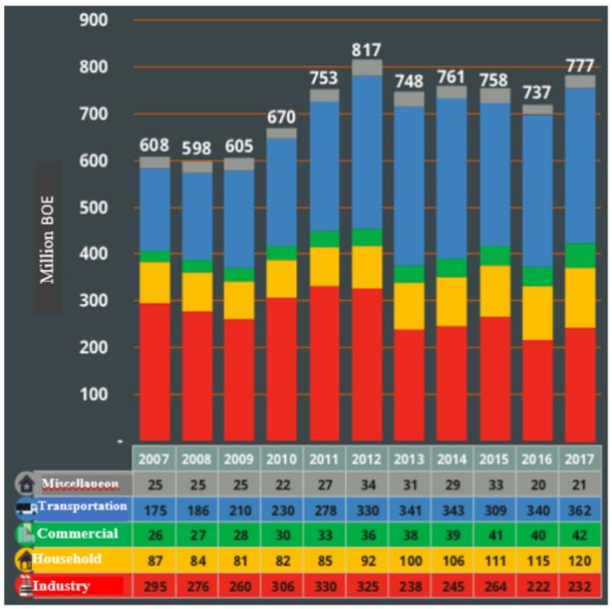

Figure 1. Indonesia's Final Energy Consumption

BOE=Barrels of Oil Equivalent.
Source: Indonesia Ministry of Energy and Mineral Resources (2019)

In the recent years, the contribution of the manufacturing industry towards Indonesia GDP is stagnating at 21 to 22% annually, even though the figure is expected to climb to 30% by 2035, demonstrating the government's confidence on the sector to remain a major contributor to the GDP. Based on data by Statistics Indonesia (2019), the manufacturing sector contributed 20.07% to the GDP in the first quarter of 2019, a slight increase from the same period in the previous year at 19.86%.

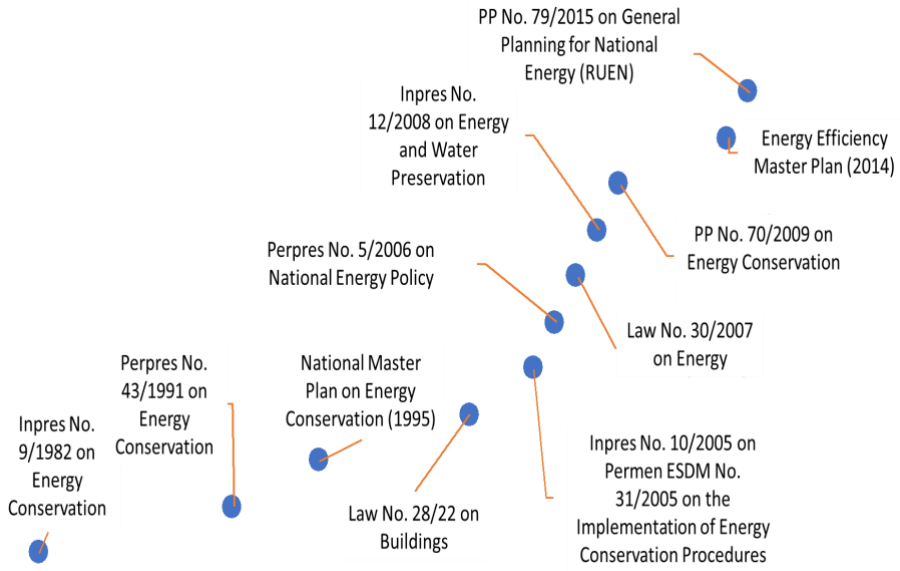

Figure 2. Laws and Regulations on Energy Conservation in Indonesia

Inpres=Presidential Instruction, Perpres=Presidential Regulation, PP=Government Regulation.
Source: Indonesia Ministry of Energy and Mineral Resources (2019)

The government has been endorsing energy conservation policies through various laws and regulations (Figure 2), and there are at least nine laws that have been established in Indonesia. In 1982, the emphasis on energy conservation was realized through Presidential Instruction (Inpres) No. 9/1982 on Energy Conservation. Then, in 2015, the General Planning for National Energy (RUEN) breathed a life to an efficient energy consumption in every sector (Indonesia Ministry of Industry, 2015).

So far, the supervision of energy conservation in the manufacturing industry has been done using the Energy Management Online Reporting (POME) platform, so there hasn't been much physical monitoring on the enforcement of the policies that can provide a solution to the manufacturing industry and its energy provision across Indonesia. The 2015-2035 National Industry Development Masterplan (RIPIN) has called for an even spread of industrialization. Therefore, it is important to find out how energy conservation has been affecting gross regional domestic product (GRDP) in 26 provinces[1] across Indonesia, especially when taking into account the situation in Java Island, where energy consumption has been rampant but energy sources are rare, and outside Java, where the situation is the other way around.

Therefore, this study intends to find out how energy intensity and economic growth in the 26 Indonesian provinces are correlated. By mapping energy intensity in each of these provinces, the study expects to provide appropriate policy recommendations, especially towards provinces who are still dependent toward non-renewable energy sources.

LITERATURE REVIEW

In energy and economic literature, several studies have attempted to discover the correlation between energy consumption and growth, energy demand by household, industries etc., and many studies have also focused on the correlation between energy consumption and climate change. However, there are not many studies focusing on energy intensity within the manufacturing industry or other, more specific fields. One of the most relevant studies was conducted by Fisher-Vanden et al. (2004) in China. Using data from 2,500 medium-large industries between 1997 to 1999, they managed to discover that the main factors in various energy intensity decrease were the changes in energy price and expenses in research and development (R&D). Meanwhile, other factors such as ownership, region, and composition of the industry were not as significant.

Nevertheless, as have been indicated in previous publications, many studies have researched the correlation between energy demand and the production side. In general, these studies can be divided into two categories. The first is the ones that focused on assessing demands of all types of energy, providing knowledge on energy substitution inputs, such as for the use of coal in generating electricity. The second category focused on the substitution between energy and other input factors, such as labor, capital, and materials. Both these categories were specifically estimated using a system from demand equation derived from the company's cost minimization using translog cost function.

Several literatures have attempted to discover the indicators of energy intensity that were related to the manufacturing industry, both in the international and national level. Various calculations have been done to determine the levels of energy intensity within nine primary manufacturing industries in India (Decker & Ray, 2011).

Reddy & Ray (2011) conducted a research to determine the indicators of energy intensity in five industry sub-sectors, namely iron and steel, aluminum, textile, pulp and paper, and cement, between 1991 and 2005. The use of energy intensity indicators can improve comparative measures between countries and provide policy designs to increase productivity and optimize energy consumption in the manufacturing industry. Meanwhile, Cole et al. (2006) discovered that there were three effects that can push down energy intensity, namely technical effect, scale effect, and composition effect. Technical effect is an increased adoption from technological advancement that impacted in lower energy intensity due to increased productivity (Batrakova & Davies, 2012; Cole et al., 2006). Then, scale effect is an increase of economic activities in a given region that can trigger increased energy use. Next, composition effect is a change in production type that can affect energy intensity (Copeland & Taylor, 1994).

METHODOLOGY

The data used in this study is secondary qualitative data from 2000 to 2005, using samples from nine manufacturing sub-sectors between 1990 and 2018 in 26 provinces across Indonesia, before eight new provinces were established after 1990. Data from the new provinces that are not included in the study have been incorporated into its origin province/region.

[1] The reason why only 26 out of 34 provinces were selected will be elaborated in Section 3 (Methodology).

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This study used the descriptive analysis method, specifically growth and share analysis on the obtained data. Growth and share analysis is used to identify the dominant, potential, slowing and

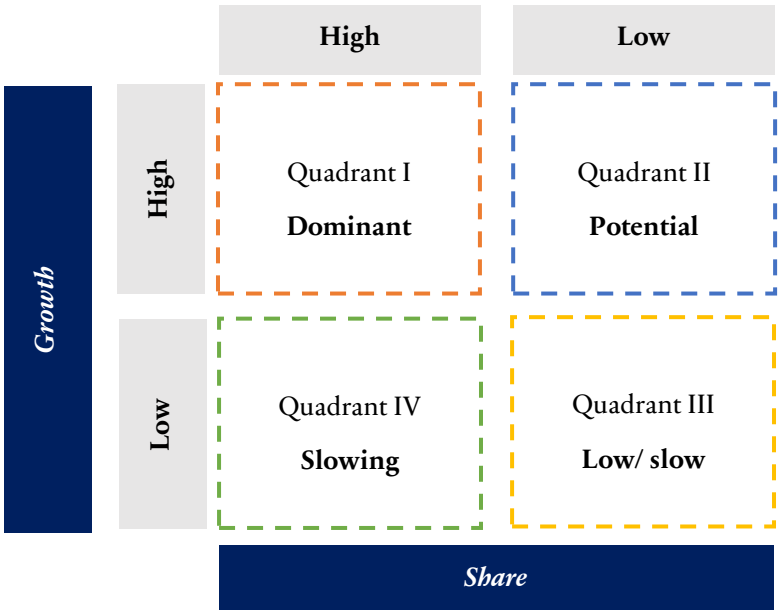


Figure 3. Growth and Share Analysis Matrix

low/slow economic factors in the manufacturing industry sub-sectors, growth, and energy intensity in 26 provinces across Indonesia prior to the expansion of new provinces. The analysis used the following matrixes divided into four quadrants (Figure 3):

a) Quadrant I – dominant (high growth and high share). From the analysis, energy intensity of manufacturing sub-sectors in this quadrant have high growth and contribution. Provinces in this quadrant also have high economic growth that is correlated to high contribution from energy intensity.

b) Quadrant II – potential (high growth and low share). Energy intensity of manufacturing sub-sectors in this quadrant have high growth but low contribution. Provinces in this quadrant have high economic growth but low contribution from energy intensity.

c) Quadrant III – low/slow (low growth and low share). Energy intensity of manufacturing sub-sectors in this quadrant have low growth and contribution. Provinces in this quadrant also have low economic growth and low contribution of energy intensity.

d) Quadrant IV, slowing (low growth and high share). Energy intensity of manufacturing sub-sectors in this quadrant show is high in contribution, but slow in growth. The contribution of energy intensity towards economic growth in these provinces are high, but the growth itself is low**.**

RESULTS AND DISCUSSION

Result of growth and share analysis on Indonesia's manufacturing sub-sectors

Based on the growth and share analysis toward energy intensity in the manufacturing sub-sectors in Indonesia between 2000 and 2015, the average growth value is recorded at -1.67, and the average share value is recorded at 0.18. Next, energy intensity in all sub-sectors were mapped based on the aforementioned quadrants in the growth and share matrix. The result can be seen in Figure 4.

Based on the growth and share matrix in Figure. 4, the analysis in each quadrant is as follows:

1) Quadrant I

   Manufacturing sub-sectors in this quadrant have high energy intensity growth and contribution. There are three sub-sectors in this category, namely pulp and printed goods, cement and non-metal minerals, and miscellaneous.

2) Quadrant II

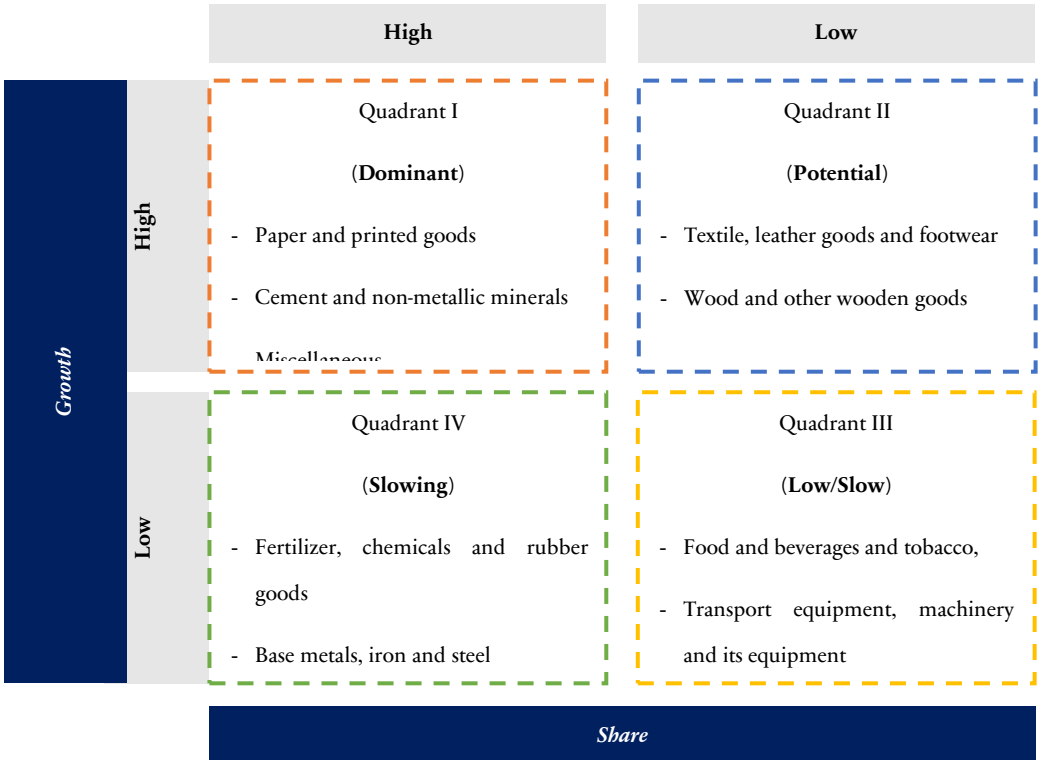
Manufacturing sub-sectors in this quadrant have high energy intensity, but its contribution is low. There are two sub-sectors in this category, namely textile, leather goods and footwear, and wood and other wooden goods.

3) Quadrant III

Manufacturing sub-sectors in this quadrant have low energy intensity growth and contribution. There are two sub-sectors in this category, namely food and beverages and tobacco, and transport equipment, machinery and its equipment.

4) Quadrant IV

Manufacturing sub-sectors in this quadrant have low energy intensity growth, but high contribution. There are two sub-sectors in this category, namely fertilizer, chemicals and rubber goods, and base metals, iron and steel.



Source: Authors' calculation.

Results of growth and share analysis on GRDP and energy intensity in 26 provinces across Indonesia

Figure 4. Growth and Share Analysis towards Energy Intensity in the Manufacturing Sub-sectors in Indonesia

The growth and share analysis at the provincial level was done to discover the growth and contribution of energy intensity towards economic growth, proxied by GDRP and energy intensity figures from each province. Using economic growth data from 1990 to 2018, the analysis resulted in an average growth value of 6.84 and average share value of 3.84. Meanwhile, from the energy intensity side, the average growth and share values are 0.77 and 1.16, respectively.

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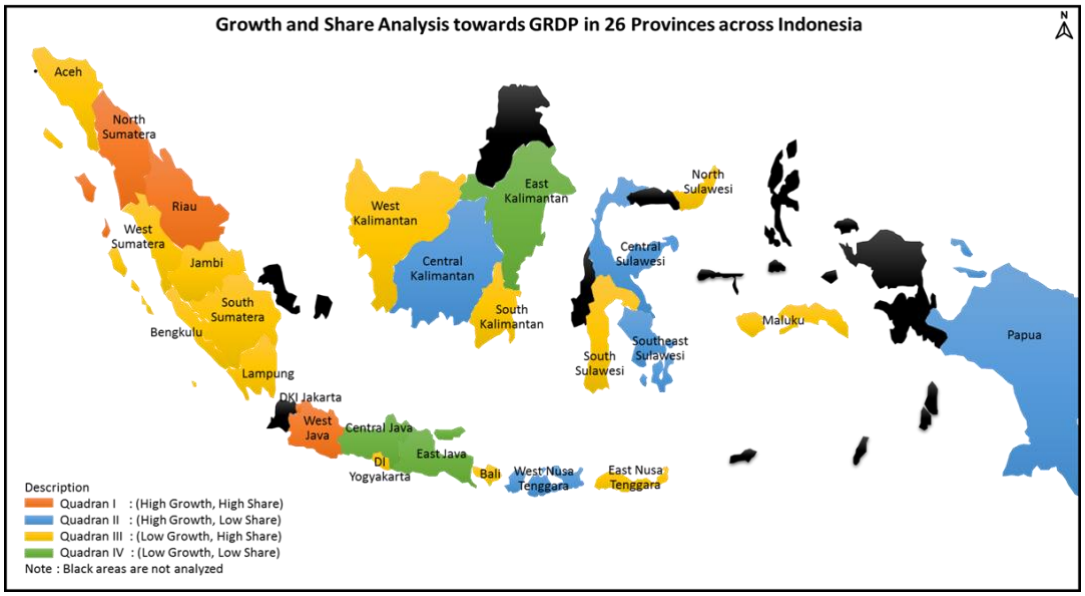

Figure 5. Growth and Share Analysis towards GRDP in 26 Provincess across Indonesia

Source: Authors' calculation.

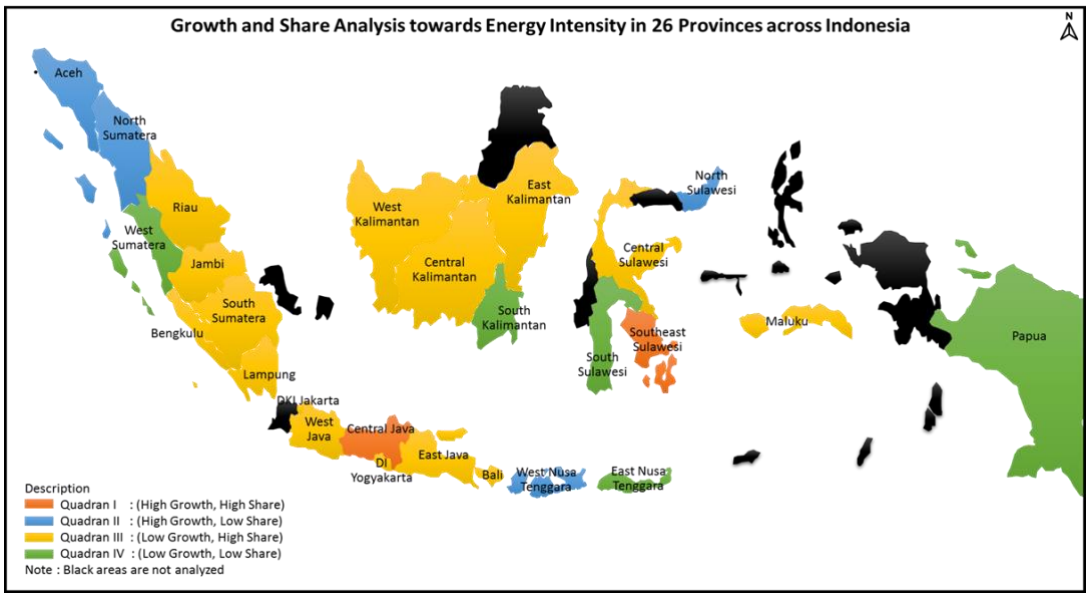

Figure 6. Growth and Share Analysis towards Energy Intensity in 26 Provincess across Indonesia

Source: Authors' calculation.

Based on the diagram mapping on the growth and matrix share in Figure 5, the results are as follows:

1) Quadrant I

Provinces in this quadrant are those with high growth and contribution of GRDP. From the economic growth analysis, the plotting results indicate that North Sumatera, Riau, DKI Jakarta, and West Java are included in this quadrant. Meanwhile, in the energy intensity analysis, provinces included in this quadrant are Central Java and Southeast Sulawesi.

2) Quadrant II

Provinces in this quadrant are those with high growth of GRDP and energy intensity but the contributions are low. From the economic growth analysis, provinces in this quadrant are West Nusa

Tenggara, Central Kalimantan, Central Sulawesi, Southeast Sulawesi, and Papua. Meanwhile, in the energy intensity analysis, the provinces are North Sumatera, Aceh, West Nusa Tenggara, and North Sulawesi.

3) Quadrant III

Provinces in this quadrant are those with low growth and contribution of GRDP and energy intensity. From the economic growth analysis, provinces in this quadrant are Aceh, West Sumatera, Jambi, South Sumatera, Bengkulu, Lampung, DI Yogyakarta, Bali, East Nusa Tenggara, West Kalimantan, South Kalimantan, North Sulawesi, South Sulawesi, and Maluku. Meanwhile, from the energy intensity analysis, the provinces are Riau, Jambi, South Sumatera, Bengkulu, Lampung, DKI Jakarta, West Java, DI Yogyakarta, East Java, Bali, West Kalimantan, Central Kalimantan, East Kalimantan, Central Sulawesi, and Maluku.

4) Quadrant IV

Provinces in this quadrant have low GRDP and energy intensity growth, but their contributions are high. From the economic growth analysis, provinces in this quadrant are Central Java, East Java, and East Kalimantan. Meanwhile, from the energy intensity analysis, the provinces are West Sumatera, East Nusa Tenggara, South Kalimantan, South Sulawesi, and Papua.

Overall, the findings of the growth and share study discussed above indicate that a number of industrial sub-sectors continue to have high energy intensities, particularly those that are part of the dominant quadrant and should therefore be the primary focus of attention. The cement, metal, and paper industry sector is one of these subsectors and is represented by the dominant quadrant in the growth and share analysis. Based on data from the 2018 BPS, the contribution of the paper industry sub-sector to the overall manufacturing industry output is just 0.69%, according to an analysis of the production generated in this sub-sector. Moreover, the other products sector came in at 0.14%, followed by the cement sector at 0.63%.

There are a lot more provinces in Quadrant III (low/slow) compared to other quadrants. From the economic growth side, this indicates that many provinces still have low growth and contribution towards the national economy. When referring to GRDP contribution from each province in 2018, the highest contributor was South Sulawesi (3.08 %), followed by South Sumatera (2.8 %), and Lampung (2.2 %). From the energy intensity side, there are 15 provinces with efficient energy intensity. There are provinces with low economic growth contribution but have high energy consumption, namely Aceh, Sumatera Barat, East Nusa Tenggara, South Kalimantan, North Sulawesi, and South Sulawesi.

On one side, differences in industry structure could have been the main factor behind the difference in energy intensity among provinces in Indonesia. Developing provinces tend to focus on improving industrialization, such as the traditional manufacturing industry, which consumes more energy. However, such situation may lead to low output for the economy. In the case of developed provinces, the condition is the other way around, where the industries tend to concentrate on sectors with low energy intensity, such as the high-tech industry that consumes little energy but provides big contribution to the economic output (Setyawan & Wardhana, 2020).

From the economic structure, the most dominant sub-sector of all the provinces is food and beverages. This industry provides the highest contribution to economic growth in Riau, South Sumatera, Bengkulu, West Nusa Tenggara, Central Kalimantan, South Kalimantan, North Sulawesi, Bali, and East Nusa Tenggara.The growth and share explanation mentioned above indicates that provinces with significant GRDP and national economic growth contributions do not have a dominant energy intensity. According to BPS data for 2018, DKI Jakarta is the province with the biggest GRDP contribution to Indonesia's national economic growth, at 17.31%. West Java comes second with a contribution of 13.09%, followed by Riau and North Sumatra, which had contributions of 5.02% and 4.95%, respectively. DKI Jakarta, West Java, and Riau are in quadrant III or have lower energy use to produce overall output when seen from the perspective of energy intensity. On the other side, North Sumatra continues to see a dramatic increase in energy intensity. According to the North Sumatra Province Strategic Plan for 2019–2023, there are a number of issues with boosting energy efficiency, including potential locations for future renewable energy production in protected forest areas. Lack of funding and staff prevent linked organizations from conducting outreach regarding energy conservation. Due to the high cost of implementing the audit's recommendations, several businesses are compelled to decline doing an energy audit. In addition, because energy-saving products are expensive, there is a lack of knowledge regarding energy conservation (Energy and Mineral Resources Agency, 2019).

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This demonstrates how the transportation sector, the province's highest contributor to economic growth, have been energy efficient. A similar result is seen in Riau, whose primary industry is food and beverages, and has been using energy efficiently. This leads to the sub-sector's high contribution towards economic growth but with low energy use (Table 1).

Table 1. OLS findings are mapped using significant provincial similarity (Source: Authors' calculation.)

Province	**OLS**	**Agglomeration**					**Leading Industry**
	Result	**2014**	**2015**	**2016**	**2017**	**2018**	
Riau	(-)	0,82	0,80	0,74	0,71	1,20	- Food and Drink - Paper and paper goods - Coal, oil, and gas refineries
Sumatera Selatan	(-)	0,39	0,36	0,44	0,49	0,82	- Food and drink - Coal, oil, and gas excavation - Rubber, rubber goods, and plastics
Bengkulu	(-)	0,23	0,30	0,40	0,36	0,58	- Food and drink - Rubber, rubber goods, and plastics
DKI Jakarta	(-)	1,08	1,05	0,68	0,91	1,39	- Means of transportation - Chemical, pharmaceutical, and traditional medicine - Metal items
Nusa Tenggara Barat	(-)	0,67	0,71	0,68	0,82	1,32	- Food and drink - Wood, wood products, and cork - Non-metal minerals
Kalimantan Tengah	(-)	0,18	0,27	0,38	0,31	0,59	- Food and drink - Chemical, pharmaceutical, and traditional medicine - Wood, wood products, and cork
Kalimantan Selatan	(-)	0,45	0,50	0,52	0,56	0,94	- Food and drink - Rubber, rubber goods, and plastics - Wood, wood products, and cork
Kalimantan Timur	(-)	0,46	0,41	0,52	0,45	0,79	- Coal, oil, and gas refineries - Chemical, pharmaceutical, and traditional medicine - Food and drink
Sulawesi Utara	(-)	0,58	0,52	0,48	0,56	1,04	- Food and drink - Non-metal minerals - Metal items
Maluku	(-)	0,23	0,27	0,65	0,53	0,77	- Rubber, rubber goods, and plastics - Food and drink - Wood, wood products, and cork
Papua	(-)	0,12	0,10	0,17	0,20	0,29	- Wood, wood products, and cork - Food and drink - Non-metal minerals
Bali	(+)	1,05	0,93	1,17	1,00	1,56	- Food and drink - Wood, wood products, and cork
Nusa Tenggara Timur	(+)	0,57	0,46	0,56	0,62	0,96	- Food and drink - Non-metal minerals

CONCLUSIONS

Results of this study show that the paper and printed goods, cement, and non-metal minerals are the most energy-intensive industry sub-sectors. Meanwhile, the food and beverages, transportations, machinery and its equipment industries have more efficient energy intensity. Then, Riau, DKI Jakarta, and West Java provinces are in the dominant quadrant for economic growth but, are in the low/slow quadrant for energy intensity, meaning that these three regions have efficient use of energy.

1) The findings of the growth and share study indicate that:

   a) Non-metallic minerals, the cement industry, and the paper and printed matter industries are energy-intensive industrial sub-sectors. However, machinery and equipment have efficient energy intensities in the food and beverage industry and the industry for transportation equipment.
   b) While the energy intensity of the provinces of Riau, DKI Jakarta, and West Java is in the low/slow quadrant, they are in the dominating quadrant for economic growth. This shows that these provinces use energy effectively, and
   c) According to the Balassa index data, agglomeration on the input side of the workforce reveals that there is little to no agglomeration in the newly constituted provinces and that even when there is agglomeration, it is minimal.

The government is encouraged to further evaluate other industry sub-sectors which are thought to consume more energy, so that energy conservation policies will be more accurate and achieving. The understanding on energy conservation policies at the regional level are not comprehensively identified compared to at the national level, leading to information gap on energy conservation and thus and reduction of productivity, whereas better knowledge of it can lower cost structure, and better technology can reduce energy consumption while maintaining or even increasing its productivity. Nevertheless, such things must be done at the next level of assessment in the energy efficiency pyramid.

1) The provincial government may take industrial agglomeration into account in order to improve energy efficiency by looking at provinces that share the same economic structure as their expansion areas;
2) The government may assess the implementation of energy conservation in Indonesia, particularly in agglomerated areas.
3) To ensure that energy-saving programs are effective in achieving goals, the government might evaluate energy-intensive industrial sub-sectors.
4) The comprehension of national energy conservation policies is not well understood at the regional level. As a result, regional energy conservation efforts are not carried out to their full potential. This occurs as a result of the ineffective socialization of incentives and disincentives derived from energy conservation, and
5) There is a need to govern incentive schemes for sectors that have adopted energy conservation.

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