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Article

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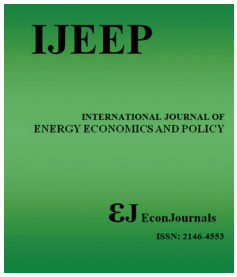

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Energy Efficiency Development in Indonesia: An Empirical Analysis of Energy Intensity Inequality

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ABSTRACT

Indonesia comprises a vast geographic region where a noticeable imbalanced of resource allocations have been impacting a significant disparity amongst regions. Some research has been conducted to measure income inequality in Indonesia, however, there was no study has been done to measure energy usage disparities in Indonesian case, specifically in the provincial level. This study proposes to investigate the disparities of energy usage levels specifically in energy intensity amongst 33 provinces in Indonesia from 2010 to 2015 by employing several indicators including Kernel Density Estimator, Gini Coefficient, Theil Index, Atkinson Index, and the Coefficient of Variation. The results capture the existence of a convergence process in energy usage across the 33 provinces in Indonesia during 2010 and 2015. Overall, this study concludes that energy efficiency process in Indonesia has been improved over the study period.

Keywords: Energy Efficiency, Disparities, Energy Intensity, Indonesia
JEL Classifications: Q43, O13, O11

1. INTRODUCTION

Indonesia comprises a vast geographic region where a noticeable imbalanced of resource allocations have been impacting a significant disparity amongst regions (Tadjoeddin et al., 2001). Energy efficiency is closely associated with the degree of regions development where diverse developmental states establish different impediment to energy conservation. In general, the evolution of a reduction in energy intensity disparities amongst regions represent a convergence to more apparent energy efficiency and conservation (Duro et al., 2010). Thus, it is essential to rigorously examine the disparities across provinces in Indonesia with regard to the energy efficiency and to investigate the level, driving forces and trends of provincial disparities in energy usage. This research is expected to present the basis of provinces energy-saving potential and formulating a better energy-saving policy.

Understanding distribution of energy usage in Indonesia also involves understanding the issues of interregional economic inequality in Indonesia. Since the reform era and decentralization process started in 2000s, the western region (including Java-Bali and Sumatera) of Indonesia has been richer than the central (including Kalimantan and Sulawesi) and eastern regions (including Maluku, Nusa Tenggara and Papua). Nevertheless, these illustrations of disparities in Indonesia have varied overtime. Since the economy of the western region of Indonesia grew faster through the 1990s, it also deteriorated the economic disparities across Western and Eastern regions of Indonesia. Researches of regional inequality in Indonesia have merged to a common model that inter-regional disparities in GDP remained constant during the 1980s, grew in the 1990s and began declining in the period of the early 2000s. Many central government policies lately have corroborated to expand and revitalize the Eastern region of Indonesia (Bappenas, 2017) to minimize income disparities. The early outcomes address that these discretions have stabilized, if not reduced income disparities across regions.

Some research has been conducted to measure income inequality in Indonesia (for instance, Akita and Lukman, 1995; Akita and

Alisjahbana, 2002; Hill et al., 2008). However, there was no study has been done to measure energy usage inequality in Indonesian case, specifically in the provincial level. It is expected that this study will contribute to the literature by measuring whether Indonesia's provinces energy usage disparities mirror those of the economic inequality. It is clear that income inequality exists at the provincial level in Indonesia and it is assumed that there is a similar pattern of energy intensity disparities exists in Indonesia which wealthier provinces consuming more energy at the subnational scale in Indonesia.

This study proposes to analyses the disparities of energy usage levels specifically in energy intensity amongst 33 provinces in Indonesia from 2010 to 2015. The meaning of the decrease of energy intensity disparities could be corresponded to the large decrease of Indonesia's energy intensity overtime that means there is a convergence to more efficient in the energy usage. The relation of GRDP and energy intensity will be shed light to explain the disparities amongst Indonesian provinces where the differences in energy intensity amongst relatively wealth and poor provinces will be analyzed further.

This study will assist to the literature in several purposes. Firstly, to our knowledge, no other study has utilized the energy consumption inequality approaches that usually employed on an international cross-country level to the national cross-provincial scale. Whereas a clear pattern relating energy consumption to GDP can be viewed on the international scale, this study expects to examine if identical relationship can be seen on a provincial level. Likewise, many studies of income inequality in Indonesia have priorly not take into account the environmental measure of development.

At the same time, there are many studies investigate factors affecting Indonesian energy consumptions to economic measures. However, to the best of our knowledge no studies have examined energy usage disparities across provincial level in Indonesia. Thus, this study expects to add to the literature by investigating whether income inequality patterns in provincial level are similar as energy usage disparities across provincial level in Indonesia. This study begins this analysis with following research questions: What is the level of energy usage disparities across provincial level in Indonesia? Is energy usage greater in wealthier provinces of Indonesia? Is the evidence showing a convergence[1] of energy usage across provinces in Indonesia?

Disparities across regions in Indonesia is potentially a result of natural resources diversity, geographical condition, human resources, cultural and ethnicities, etc. This diversity may provide advantages on the one hand, but on the other hand it may potentially become a source of social and political instability. Therefore, providing comprehensive views of disparities issues across provincial level in Indonesia is essential in order to formulate a sound development planning and policies to reduce disparities problems across regions.

1 The concept of convergence relates to the decrease of a development indicator dispersion, for instance distribution of per-capita income across regions, whereas in this study is represented as per-capita energy consumption, total energy consumption and energy intensity distribution across provinces.

2. LITERATURE REVIEW

The dynamics of energy intensity of GDP can be very varied across countries and period of time (Roca and Alcántara, 2002; Alcantara and Duro, 2004). Some research has been done to examine the inequalities of energy usage evolution and economic indicators differences (Grossi and Mussini, 2017; Sáez-Pascual et al., 2017; Lawrence et al., 2013; Duro et al., 2010; Sun, 2002). Those studies showed that the dynamics of energy intensity might reflect the differences in the economic structure and technologies level in a country.

A recent study of energy usage disparities was examined by Grossi and Mussini (2017). They investigated the inequality of energy intensity amongst EU-28 countries from 2007 to 2012 using Zenga index. To determine the unequal components of the energy intensity from the bottom to the top of distributions, their research broke down the inequality of energy intensity into three effects, namely final energy intensity, energy transformation and their interactions in energy intensity inequality. They conclude that the final energy intensity performs a major role in explaining energy intensity inequality distribution. Another study was investigated by Sáez-Pascual (2017), where they analyzed energy consumption inequality in European Union countries (EU-15) from 2005 to 2014 employing Gini Coefficient, Atkinson, Generalized Entropy Indices and Lorenz Curve. By grouping the EU-15 into four clusters: Mediterranean, Nordic, Continental and Anglo-Saxon, they found that there was an inwardly small shift in the Lorenz Curves and the Gini Index has decreased around 2% during 2005 to 2014 indicating a decrease in inequality. A similar finding of the decrease in energy consumption inequality also concluded by Lawrence et al. (2013) for world energy consumption per capita during 1980 to 2010. By employing the U.S. Energy Information Administration (EIA) data, they discovered an upward shift in Lorenz curves and the Gini Index had decreased significantly during this period.

Employing OECD countries data from 1980 to 2006, Duro et al. (2010) developed a methodology to decompose inequality in energy consumption per capita into explanatory components, namely energy intensity, affluence and interaction. They concluded that the decrease of energy intensity differences amongst countries appeared the most significant role in the decrease of inequality in energy consumption per capita, while the affluence factor (differences in GDP level per capita) serves as the main factor causing the high inequalities in energy consumption per capita. Using the same sample of OECD countries, Sun (2002) examined the differences of energy intensities between 1971 and 1998. By employing mean deviation, he found that the level of difference of energy intensities amongst OECD countries decreasing over the study period. Another recent study by Setyawan (2020) found that the aggregate energy intensity in ASEAN-6 countries were declining. By comparing the economy-wide energy intensity performances of Vietnam, Singapore, Thailand, Malaysia, the Philippines and Indonesia, he concluded that all these countries showed a shift in industry value added to more energy-intensive industries.

Against the background of those researches of inequality measures to energy usage, this study primarily assists to the existing literature in providing measurements of the variances of energy usage across regions. Instead investigating the disparities of energy usage in a worldwide level, this study focusing its investigation in a national level across 33 provinces in Indonesia. Thus, the nation-state level analysis in this study will be more applicable, since the discussions are based on the character of the specific area, whereas it is expected to shed light on the specific problems caused by changes of government policies.

3. METHODOLOGY AND DATA

As mentioned earlier, many research has been employed traditional inequality measures to investigate the distributions of energy economic indicators (Grossi and Mussini, 2017; Lawrence et al., 2013; Duro et al., 2010, Ezcurra, 2007; Sun, 2002). One of the main features of these indexes is that every measure set different weights to the variable distribution, thus in some cases the yield may potentially differs over time (Duro, 2012). Thus, in order to provide a more robust analysis and prevent biased conclusions, this study employs several indicators that are distinct in their observations. Amongst of the indicators employ in this study including Gini Coefficient (Gini, 1912), Theil Index (Theil, 1967), Atkinson Index (Atkinson, 1970), and the coefficient of variation.

3.1. Gini Index

The Gini index is one of the important tools to comprehensively analyze disparities in distribution of income. This index is generally used with the Lorenz Curve in predicting the level of equitableness of income distribution, where the coefficient is often applied to estimate gaps of income across regions and individual, for instance the degree of inequality. Following the aforementioned principles, the formula of Gini Index to analyze regional energy usage disparities can be expressed as:

$$G = \frac{1}{2\mu}\sum_{i=1}^{n}\sum_{j=1}^{n} p_i p_j \left| e_i - e_j \right| \quad (1)$$

Where $e_i e_i$ and $e_j e_j$ denote the energy usage[2] of provinces i and j, respectively, $p_i p_i$ and $p_j p_j$ denote the relative weights of provinces i and j, respectively, n represents the number of provinces and $\mu\mu$ denotes the average energy usage of all provinces.

3.2. Theil Index

$$T(\beta) = \frac{1}{\beta(\beta-1)}\sum_{i=1}^{n} p_i \left[\left(\frac{e_i}{\mu} \right)^{\beta} - 1 \right] \quad (2)$$

The $\beta\beta$ parameter measures the sensitivity of the distributional changes, where the smaller $\beta\beta$ value indicates the more sensitive the index to the bottom ranking of observations.

2 In this study, Energy Usage is defined as Total Energy Consumption per Province, Energy Consumption per capita per province, and Energy Intensity per Province.

3.3. Atkinson Index

$$A(\varepsilon) = 1 - \left[\sum_{i=1}^{n} p_i \left(\frac{e_i}{\mu} \right)^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}} \qquad \varepsilon \neq 1 \quad (3)$$

$\varepsilon\varepsilon$ denotes as the degree of social inequality aversion, where $\varepsilon=0\varepsilon=0$ means there is no aversion to inequality and $\varepsilon=\infty\varepsilon=\infty$ means the index only captures the poorest observation.

3.4. Coefficient of Variation

$$CV_{\omega} = \frac{\sigma_{\omega}}{\mu}$$

$\sigma_{\omega}\sigma_{\omega}$ is the weighted standard deviation.

3.5. Kernel Density Estimator

Many studies have measured the possible existence of convergence in cross-country energy intensity levels (Nielsson, 1993; Goldemberg, 1996; Mielnik and Goldemberg, 2000; Markandya et al., 2006; Ezcurra, 2007). However, there are a limited study examine a cross-province convergence within a country. Hence, this study also aims to contribute to the literature by examining convergence across 33 provinces in Indonesia over period 2010 and 2015.

In addition to the previous energy usage inequality indices, this study also provides its analysis by examining the distribution of energy usage across 33 provinces by employing a non-parametric technique, namely Kernel Density Estimator (Ezcurra, 2007; Quah, 1993; 1996).

$$f(e_t) = \frac{1}{nh_t}\sum_{i=1}^{n} K\left(\frac{e_t - e_{it}}{h_t} \right) \quad (5)$$

Where $e_{it}e_{it}$ denotes the energy usage of province i in year t, $h_t h_t$ is the smoothing parameter and K represents a kernel function that is based on Gaussian Kernel Function.

3.6. Dataset

This study compares different types of energy usage data, including energy consumption, energy consumption per capita and energy intensity. Final energy consumption, population and GDP at provincial level will be derived from the Indonesia's statistics bureau (BPS), Ministry of energy and mineral resources (ESDM), national gas company (PGN) and national fuel company (PERTAMINA) (Table 1).

4. ANALYSIS

Indonesia has large diversities not only in geographical conditions and natural reserves, but also in population density and energy consumption patterns. In addition, there is an obvious difference of economic development amongst Indonesia's urban and rural areas, leading to discrepancies in energy consumption and economic production. As a result, a different structure has been established in consuming energy resources in Indonesia, where most of energy

is used in the cities.

4.1. Descriptive Analysis

Several variables analyze in this study including Population, GRDP, GRDP Per Capita, Energy Consumption, Energy Consumption per Capita, and Energy Intensity.

4.1.1. Population

Based on the Figure 1, it can be seen that the Indonesia's population are mostly concentrated on the Jawa+Bali and Sumatra islands (accounted around 80% of the total Indonesia's population), while the Eastern region including Kalimantan, Sulawesi, Maluku, Nusa Tenggara and Papua only accounted around 20% of the total population. The highest population is in Jabar (around 43 million in 2010 and 47 million in 2015) followed by Jatim and Jateng. While the smallest number of population is residing in Papua Barat (<1 million in 2015). Based on Kuncoro (2013), the high-density population in Java and Sumatera have contributed positively to more than 90% of all Indonesia's manufacturing employment, whereas other regions only played minor role.

4.1.2. Gross regional domestic product (GRDP)

This study employing GRDP as a parameter to represent regional income, whereas GRDP describe as total value added generated by the entire economy per province for the whole year.

Table 1: Dataset used in this research and its source

Data (Yearly)	National	Provincial	Source
Indonesian statistics	√	√	BPS
Provincial statistics		√	BPS
Energy Statistics of Indonesia	√		ESDM
Electricity statistics	√	√	ESDM
National Economic Survey (SUSENAS)	√	√	BPS
Industrial Survey Statistics	√	√	BPS
GRDP Province based on sector	√	√	BPS
Data of Fuel and Gasoline Sales by PERTAMINA		√	PERTAMINA

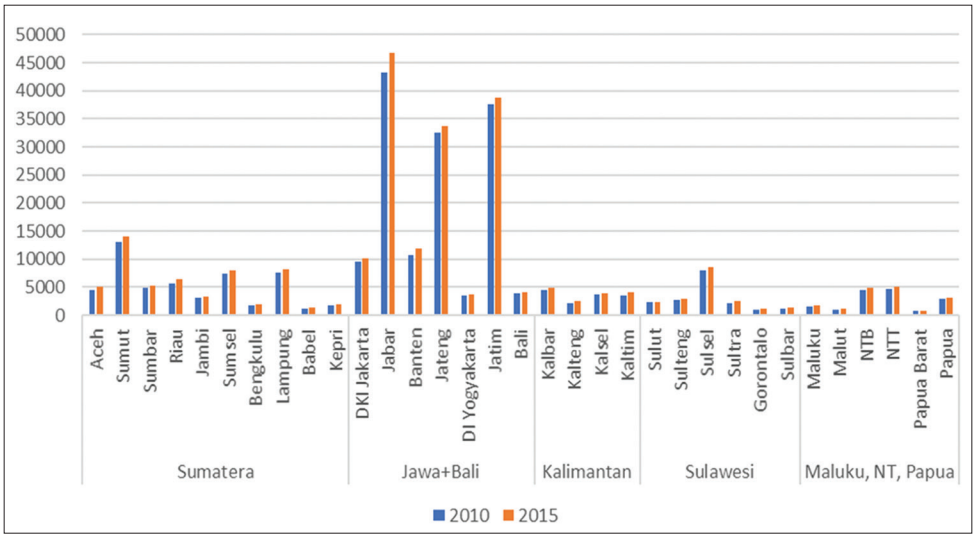
From Figure 2, it can be seen that the GRDP distribution across provinces in 2010 and 2015 shows a high level of inequality, whereas the largest share of GRDP is concentrated in Jawa+Bali and Sumatera Regions. The GRDP share from these regions in 2010 and 2015 reached approximately 81% of the national economy, where around 58% contributed by Jawa+Bali and approximately 22% came from Sumatera. Means that Eastern Region (including Sulawesi, Nusa Tenggara, Maluku and Papua) only contributes around 20% of the national income. DKI Jakarta contributes the highest GRDP share followed by Jatim and Jabar, whilst both Malut and Gorontalo contribute the least share. Since 2000, Indonesia's economic activities has been concentrated in Java and Sumatera Island, where the predominant role is heavily driven by industrial sector (Kuncoro, 2007).

4.1.3. GRDP per capita

As to measure regions prosperity, this study employs GRDP province per capita which divides total GRDP per Province to the number of province population. The higher the GRDP per capita means the higher the region's wealth, in other words the value of GRDP per capita represents the province wealth level.

Figure 3 shows the economic disparities across provinces are quite high because of some provinces have GRDP per capita much larger than the national average. The highest GRDP per Capita in 2015 is DKI Jakarta, followed with Kaltim, Riau and Kepulauan Riau (Kepri), while the least are NTT and Maluku. DKI Jakarta has the highest GRDP per capita since it is the capital city of Indonesia where also the center of industry, services and trade. Additionally, the abundance of natural resources such as oil and gas, mining materials, and forest resources have brought Kaltim become the second largest of GRDP per capita across provinces in Indonesia. Following Kaltim, the Riau and Kepri also has a quite high GRDP per capita due to the existence of Batam city as a center of industrial activity and international trade. On the other hand, some provinces have lack of resources that made their GRDP per capita much below the national average for instance NTT and Maluku.

Figure 1: Indonesia population (in thousand) by provincial and island



The level of economic activity in Jawa+Bali and Sumatera are more advanced than other regions, it can be seen from the level of income per provinces in these regions. Economic developments in Jawa+Bali and Sumatera are mostly dominated by the secondary and tertiary sector such as, processing industries, manufacturing and services. On the other hand, the economic activity development of the outside Jawa+Bali and Sumatra more concentrates on primary sector, i.e., agriculture and mining, whereas the secondary and tertiary sectors growth is relatively slow.

4.1.4. Energy consumption

The distribution of inter-provincial energy consumption in Indonesia also shows high disparities. Based on Figure 4, the total energy consumption per provinces from 2010 to 2015 indicates that energy consumption mostly concentrates in Jawa+Bali and Sumatera

Figure 2: Indonesia GDRP (in billion rupiah) by province and island

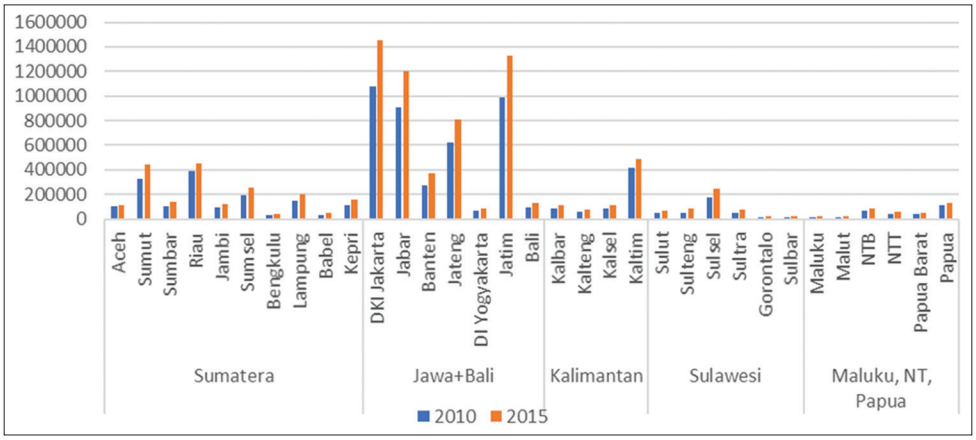


Figure 3: Indonesia GDRP per capita (in million rupiah) by province and island

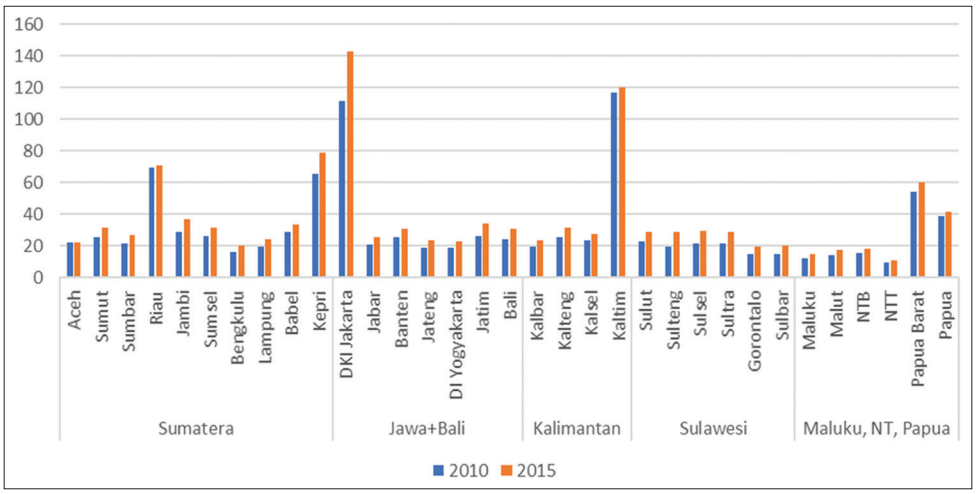
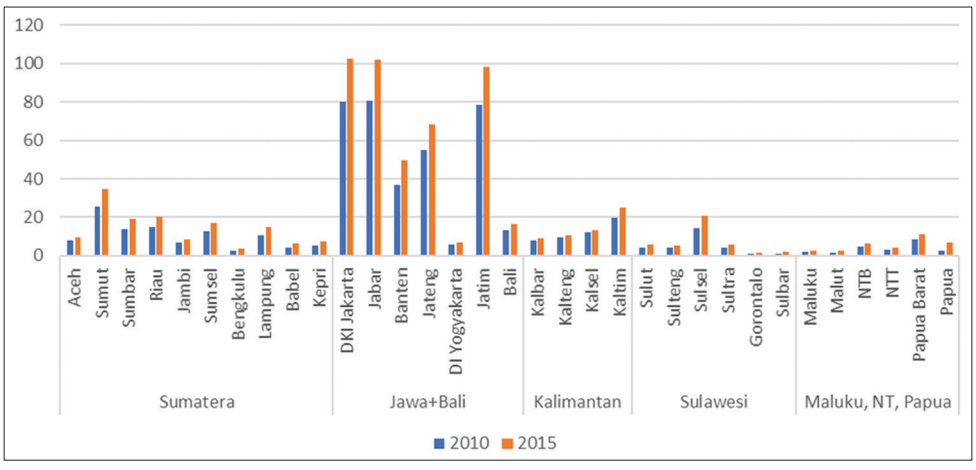


Figure 4: Energy consumption (MBOE) by province and island



Regions. The highest energy consumption is in DKI Jakarta and followed with Jabar and Jatim. While on the other hand, the lowest energy consumption lies in Gorontalo, Sulbar and Maluku.

4.1.5. Energy consumption per capita

Disparities in energy use between regions can be illustrated by province energy consumption per capita. Figure 5 shows that the disparities of energy consumption per capita across provincial level in Indonesia are quite high due to some provinces have more energy consumption compare to the national average. Employing data 2010 and 2015 for 33 provinces, the largest energy consumption per capita is DKI Jakarta and followed by Papua Barat, while the least is coming from NTT and Maluku. Papua Barat[3] is a resource-based province, which is known as a major oil producer and nature-based tourism activities (i.e., Raja Ampat marine and diving). Even though, Papua Barat wealth of resource, they have sparsely population. Thus, this condition possibly boosts its energy consumption per capita.

3 PT Freeport Indonesia is located in Papua which is one of the largest mining company (mined gold and copper). This company contributes more than 50% of Papua's economy. In addition, around 42% of West Papua's GRDP is contributed by British Petroleum (mined LPG project in Bintuni).

4.1.6. The income per capita and energy consumption per capita

Figure 6 exhibits the amount of energy consumption per capita in Jawa+Bali and Sumatra region are consistent with the level of economic activity in these regions (Western Indonesia) which is far more advanced than those outside of Jawa+Bali and Sumatera (especially Eastern Indonesia).

4.1.7. Energy intensity

In order to measure the level of energy efficiency by regions, this study proposes to use energy intensity ratio. This ratio measures the level of regional energy intensity by dividing total energy consumption per province to total GRDP per province. The disparity and improvement of energy intensity by province can be seen from Figure 7. The lower the value of energy intensity by province overtime represents that the province has improved their energy efficiency. While, on the other hand, the increasing energy intensity by province indicates a deterioration in energy efficiency level.

Figure 7 demonstrates the level of energy intensity across 33 provinces in 2010 and 2015, where the ratio tends to be varied across provinces. It can be seen that there are some provinces improve their energy intensity overtime, such as DKI Jakarta,

Figure 5: Energy consumption per capita (BOE/capita)

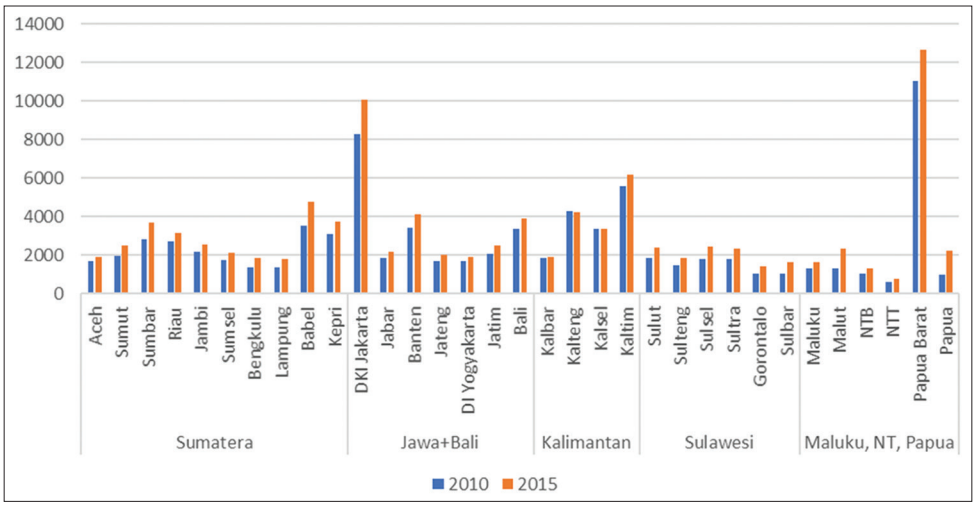


Figure 6: The income per capita and energy consumption per capita by provinces in 2015

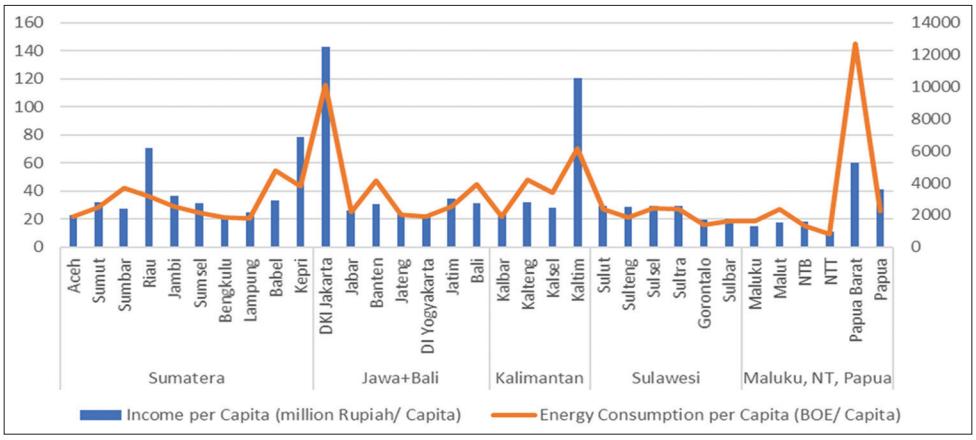


Figure 7: Indonesia energy intensity by province and island

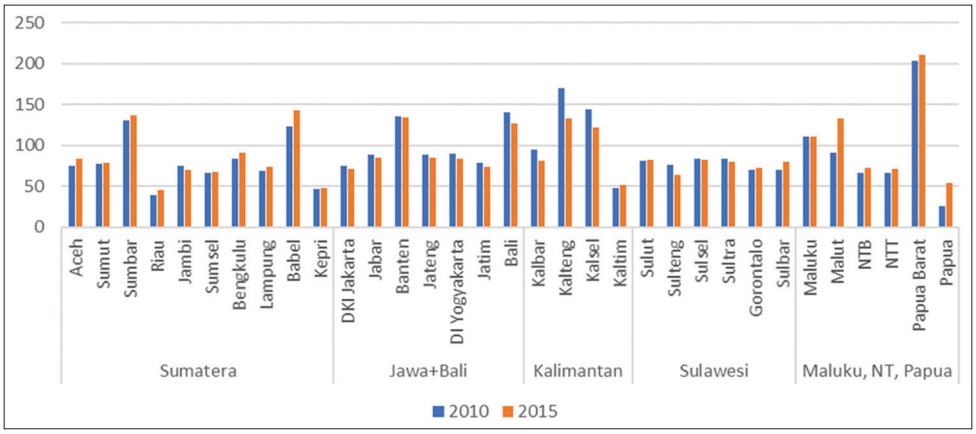
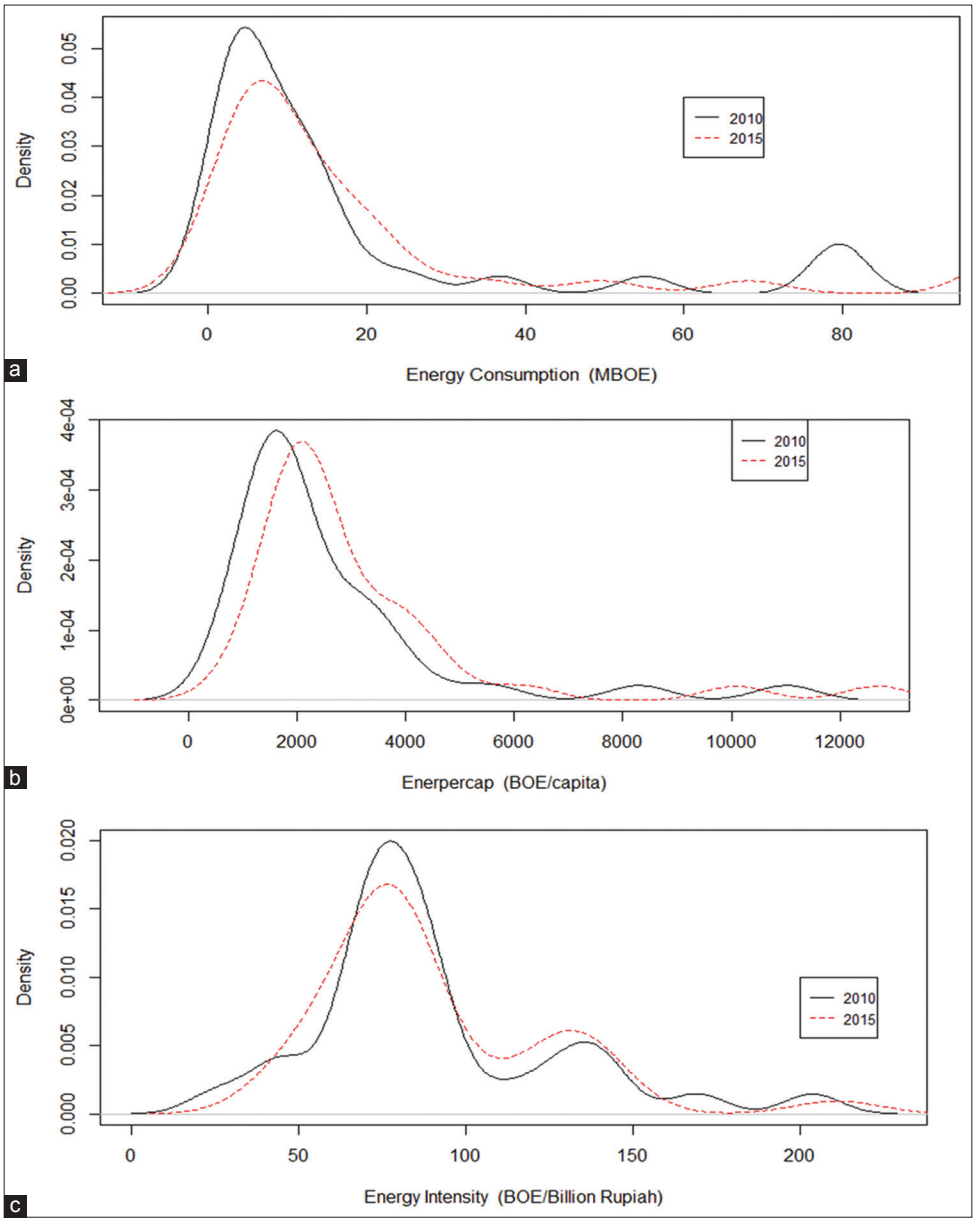


Figure 8: Density function of Indonesia energy usage distribution 2010 and 2015. (a) The distribution of total energy consumption 2010 and 2015. (b) The distribution of energy consumption per capita 2010 and 2015. (c) The distribution of energy intensity 2010 and 2015



Jabar, Jateng, DI Yogyakarta, Jatim, Bali, etc., while some other provinces have worsened its energy intensity on this period, including Papua regions and most of the eastern Indonesia's region.

4.2. Indices

This study began the analysis of energy usage disparities by examining the distribution of energy usage across 33 provinces by employing a non-parametric technique, namely Kernel Density Estimator.

Figure 8 presents the results of density function of energy usage distribution during 2010 and 2015 at 33 provinces in Indonesia. It shows that the energy usage in 2010 did not remain steady compare to the situation in 2015. The results capture the presence of a convergence process in energy usage across the 33 provinces in Indonesia during 2010 and 2015. However, the overall trend of convergence is still very modest, requiring for a longer period of observation.

To comprehensively analyze inter-regions disparities in energy usage, this study calculates different types of inequality measures as follows.

Table 2 shows the four different inequality measures including Gini Coefficient, Theil Index, Atkinson Index and Coefficient of Variance during 2010 and 2015 across 33 provinces in Indonesia. All the inequality measures in this table agree that disparities in energy usage decreased from 2010 to 2015. For instance, the level of disparity in energy intensity decreased between 2010 and 2015, with a Gini Coefficient of 0.19, Theil index of 0.06, Atkinson index of 0.03 and Coefficient of Variance approximately 0.38. Besides the energy intensity index, the other energy usage disparity indexes (including Energy consumption and energy consumption per capita) also showed similar results. Thus, in spite of the different measurement methods, the results of these indexes represented good consistency and mutually verified of the validity of the methods computed. Hence, the choice of one measure over another is not a key point in the discussion of energy usage distribution in this paper.

Table 2: Indices result

Measure	Year	Total energy consumption per province	Energy consumption per capita per province	Energy intensity per province
Gini	2010	0.59	0.36	0.21
	2015	0.58	0.33	0.19
Theil	2010	0.65	0.24	0.08
	2015	0.61	0.21	0.06
Atkinson	2010	0.29	0.11	0.04
	2015	0.27	0.09	0.03
Coefficient variance	2010	1.34	0.82	0.41
	2015	1.31	0.76	0.38

One of the driving forces behind the decreasing trend of energy usage disparities in Indonesia is the implementation of energy conservation law. Indonesian government has enacted the energy conservation law in 2007 and the related acts were formally implemented since then. The enforcement of the energy conservation act has increased public awareness for preserving energy usage over the entire nation and setback the raising trend in the regional disparities. In addition, to reduce budget allocation for energy subsidies in the state budget, Indonesian government has alleviated the fossil fuel subsidies gradually since 2005. Furthermore, the government also vigorously address the issue of global climate change by implementing National Action Plan for Greenhouse Gas Emissions Reduction since 2011. These policies have been enforced to the regional level, which necessarily encouraged energy efficiency efforts in each province in Indonesia. Therefore, those reasons may become the causes why the energy intensity in Indonesia continually decreased and the disparity in provincial energy efficiency constantly narrowed.

4.3. Spatial and Temporal Changes of Energy Usage of 33 Provinces

Based on Figure 9, in 2015, the top nine provinces with the most intensive energy intensity were Papua Barat, Kalteng, Babel, Malut,

Figure 9: The total of Indonesia GDRP and energy intensity by Provinces in 2015

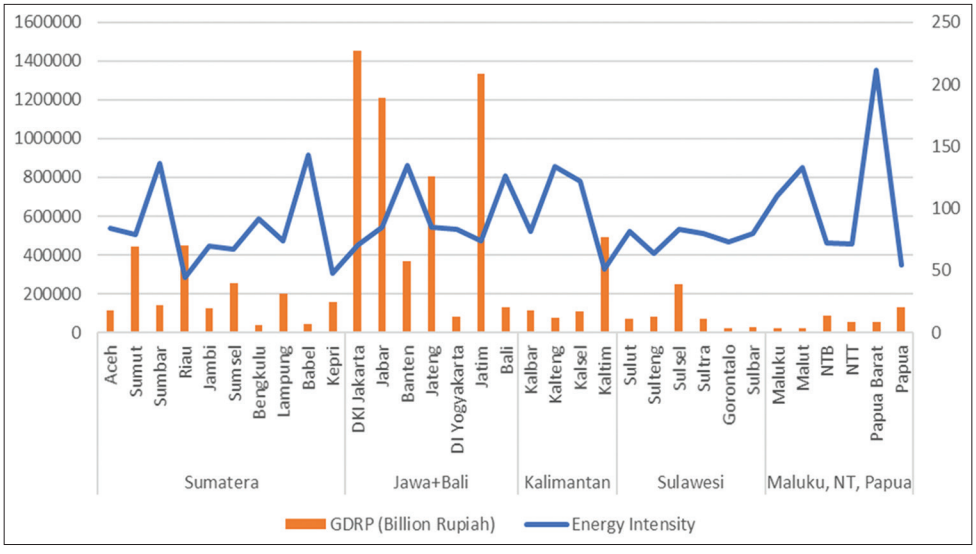
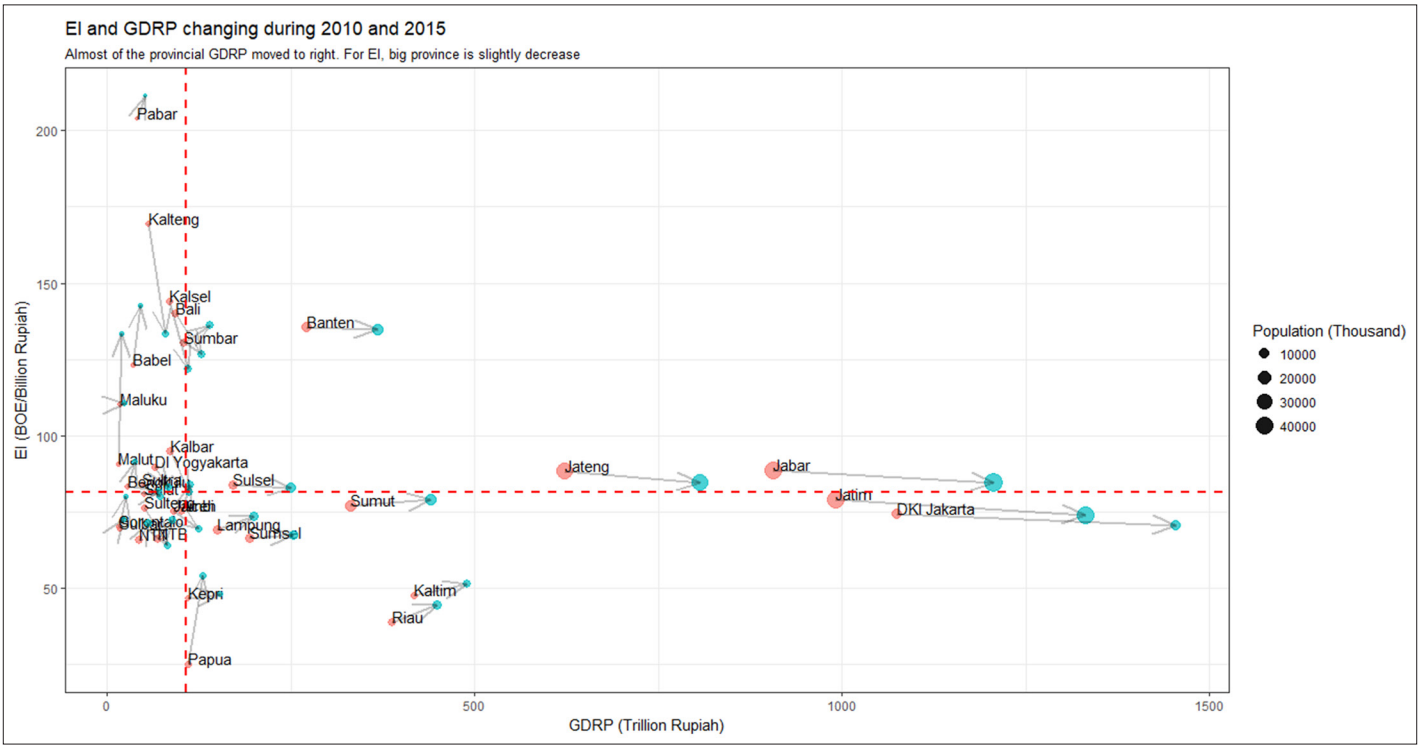


Figure 10: The changing of energy intensity and GDRP during 2010 and 2015



Maluku, Kalsel, Bali, Sumbar and Banten, whereas the bottom five provinces with the least energy intensity were Papua, Kepri, Riau, Kaltim, DKI Jakarta and Sumsel; respectively. Industrial structure may become the main factor behind the big difference of energy intensity among the different provinces in Indonesia. The underdeveloped provinces are focused on the high intensive industries like traditional manufacturing industry, which employs more energy but relatively less in supporting its economic output. On the other hand, the developed regions are more concentrated on the lower-intensive industries like high-tech industry, that utilize less energy but relatively contribute more to economic output.

4.3.1. Energy intensity and GRDP

From Figure 10, there is an obvious spatial difference in the relationship between GRDP and Energy Intensity across 33 provinces in Indonesia. In this schematic diagram, the red circle represents total population in 2010, while the blue circle represents total population in 2015. In this diagram, it can be found that Banten, Sulsel, Jateng, Jabar and Sumbar are in the Quadrant I with high energy intensity level and high GRDP. Those provinces indicated a slight reduction in energy intensity during 2010 and 2015. While, on the other hand, the capital city (DKI Jakarta), Jatim, Kaltim, Riau, Sumut, Lampung, Sumsel, Kepri and Papua are in Quadrant II. This quadrant represents the most ideal quadrant since it indicates a lower energy intensity and high economic output (GRDP) compare to the other average provinces. The worst quadrant is in quadrant IV, where this quadrant shows a high energy intensity and low economic output. Some of the provinces that are in this quadrant are Pabar, Kalteng, Kalsel, Maluku, Malut and Babel. The rest of the provinces are in Quadrant III with low energy intensity and low economic output, including Sultra, Sulut, Sulteng, NTT, NTB, Jambi, Papua, Bengkulu, Gorontalo and Aceh. Most of the provinces located in Quadrant III are considered less developed areas, where the economic development and energy consumption are still in relatively low levels.

5. CONCLUSION

The results of Kernel Density Functions capture the presence of a convergence process in energy usage across the 33 provinces in Indonesia during 2010 and 2015. In addition, all the inequality measures considered in the study (including: Gini Coefficient, Theil Index, Atkinson Index and Coefficient of Variance) agree that disparities in energy usage decreased from 2010 to 2015. Based on those results, this study concludes that energy efficiency process in Indonesia has been improved over the study period. This result is aligned with the study of Duro et al. (2010) that hypothesized the evolution of a reduction in energy intensity disparities amongst regions represent a convergence to more apparent energy efficiency and conservation.

This study identifies main provinces with having largest resources that become the source of disparities amongst other provinces, including DKI Jakarta, Kaltim, Riau, Aceh, Banten, Jabar, Jatim, Sumut and Papua. These provinces have one characteristic which is strong resource-based economy. DKI Jakarta is the capital city of Indonesia where also the center of industry, services and trade. Papua Barat and Papua are both wealth from gas mining and non-oil, including copper and gold. Aceh and Kaltim are dominated by forestry products, gas and oil. Riau has more diverse activities not only natural resources (i.e., oil, gas and crops) but also becomes a center of export manufacturing that strongly connected to Singapore. While other provinces like Banten, Jabar, Jatim, and Sumut grew faster than other provinces due to having high density population and advance airports and seaports.

There are some possible factors influencing economic disparities across provinces in Indonesia. Firstly, the most classic problem is the resources disparities amongst provinces. Those regions who have abundant natural resources, will not facing problems to extend their economic activities and become the center of growth. While those regions who have lack of resources, are fall behind compare to the resourceful regions. Secondly, different stage of infrastructure development amongst provinces. An advance infrastructure will encourage economic activities through smoother production process and better services. The level of development differences can be seen from the geographic characteristics, most provinces located in Western Indonesia (including provinces in Jawa+Bali and Sumatera) having more developed infrastructure. While, on the other hand, some other provinces located in Eastern Indonesia (including Kalimantan, Sulawesi, Nusa tenggara and Papua) having more moderate development. The difference infrastructure development also occurs between rural and urban areas; center of growth and hinterland and border areas; and Java and outside Java Island. Thirdly, different financial capacities. Most wealthier provinces have better financial capacities that can leverage its economic activities.

Those factors above not only affect Indonesia's economic disparities, but also influences its energy consumption disparities. Based on the previous preliminary data analysis of 33 provinces from 2010 to 2015, it can be seen that there are similar characteristics of regions and provinces who have the highest income (GRDP) will be followed with highest energy consumption, such as DKI Jakarta. Whilst, those having smallest income will also have smallest energy consumption, for instance Nusa Tenggara. In addition, further investigation shows that those provinces having largest income per capita will have largest energy consumption per capita, and vice versa.

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