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**Article**

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**Kontakt/Contact**
ZBW – Leibniz-Informationszentrum Wirtschaft/Leibniz Information Centre for Economics
Düsternbrooker Weg 120
24105 Kiel (Germany)
E-Mail: *rights[at]zbw.eu*
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# Energy Efficiency in OIC Countries: SDG 7 Output

**Aam S. Rusydiana[1], Nisful Laila[2]*, Naelati Tubastuvi[3], Mohamad Andri Ibrahim[4], Lina Marlina[5]**

[1]Researcher at Sharia Economics Applied Research and Training (SMART), Indonesia, [2]Faculty of Economic and Business, Airlangga University, Indonesia, [3]Faculty of Economic and Business, University of Muhammadiyah Purwokerto, Indonesia; [4]Faculty of Shariah, Universitas Islam Bandung, Indonesia; [5]Faculty of Islamic Studies, Siliwangi University, Indonesia.
*Email: nisful.laila@feb.unair.ac.id

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**ABSTRACT**

Over the past few decades, countries in the Association of Islamic Cooperation Organizations (OIC) have reached various levels of economic development. At present, increasing energy access is one of the goals to be achieved by ensuring affordable, reliable, sustainable and modern energy access. This study aims to measure the effectiveness of energy access based on the indicators of the seventh sustainable developmet goals (SDGs) in 50 countries that are members of the OIC during the period 2010-2017. Efficiency measurements are carried out using the Data Envelopment Analysis (DEA) method. The productivity measurement is done by using the Malmquist Productivity Index (MPI). The results showed that Yemen was the country that had the highest rate of increase with a TFP value of 1.194. While the State of Egypt was the country that experienced the largest decline with a TFP value of 0.821. On the other hand, there are differences in the level of efficiency regionally, where Muslim countries in the European continent are then followed by the countries of the West Asian region in the second position and the third position is the central African region which is superior to the region Other Africa.

**Keywords:** Sustainable Developmet Goals, Data Envelopment Analysis, Efficiency, Energy Access, Islamic Cooperation Organizations
**JEL Classifications:** O1, 05, Q4

## 1. INTRODUCTİON

The Sustainable Development Goals (SDGs), announced at the 2015 OIC summit, bring new perspectives for member countries in facing the challenges of global development. With 17 goals and 169 targets, it is expected to encourage the development of OIC countries that are more comprehensive in a world perspective. Energy is the seventh SDGs point which aims to eventually each country can increase international cooperation to facilitate access to research and clean energy technologies, including renewable energy, energy efficiency and fossil fuel technologies that are more advanced and clean (Kumar & Jan, 2014), and promote investment in energy infrastructure and technology clean energy and expanding infrastructure and improving technology (Saudi et al., 2019) to supply modern and sustainable energy services in developing countries (Gamoori et al., 2017), especially the least developed countries, small island developing countries, and landlocked developing countries, according to the support program each. Energy sources are very important for the survival and economic growth of a country (Saddam, 2015). Sagat energy is needed for facilities in producing food and health equipment, agriculture, education, information, and other infrastructure facilities. In the last decade, energy demand has increased dramatically in the agriculture and manufacturing sectors to increase the efficiency of production factors (Huang et al., 2008). Energy demand continues to increase every day while there are energy sources that can not be renewed so that if there is a lack of energy will affect the economic growth of a country.

Over the past two decades, there has been an increase in competition in the crude oil, electricity and natural gas sectors of several OIC countries (Konac, 2004). Therefore, there is an

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increase in attention to energy issues in OIC countries and the making of policies to achieve efficient use of energy (Mekhilef et al., 2014). In developing countries, based on the level of economic growth, population growth, and industrialization there is a rapid increase in energy consumption (Omri and Kahouli, 2014; Amri, 2016; Ibrahiem, 2015).

To measure the level of energy sources in OIC countries between the periods observed, this study uses DEA analysis. DEA specifically looks at the level of efficiency of each unit between one period with another period, so that it will be seen changes in the level of efficiency used based on predetermined inputs and outputs. The Malmquist Index is also used to analyze changes in efficiency from one period to the same year to measure the stability of performance efficiency.

## 2. LITERATURE REVIEW

Energy access efficiency is a concept that shows the ratio of the results of a comparison between input and output. Both ratios indicate that efficiency and productivity can be controlled by manipulating input and output management, or even both. Efficiency and productivity can be used to measure the performance of a unit of economic activity. An activity can be called efficient if the effort that has been done provides maximum output, both in quantity and quality. An activity can also be said to be efficient if with a minimum effort can achieve a certain output.

Muslim countries are rich in energy reserves, including countries that are members of the OIC. Overall, OIC member countries have 63% of the world's crude oil and 62% of natural gas production. Saudi Arabia is the largest oil producing country with a total of 18% of total world oil reserves. Apart from Saudi Arabia, Iraq, Kuwait and the UAE are also the largest oil producers. Whereas coal, which has been the main energy source since the 18th century, OIC countries only have 5% of the total coal reserves in the world. The average growth of energy production in OIC member countries is 2.4% with an average primary energy consumption rate of 4% (Haktanir, 2004). Bahrain, Brunei Darussalam, Kuwait, Libya, Oman, Qatar, Saudi Arabia, Turkmenistan and the United Arab Emirates are clean energy exporters, producing 100% electricity from fossil fuel sources.

Based on research conducted by Sopian et al. (2011) on Strategies for the application of renewable energy in OIC countries. In his research found that although some countries are able to produce energy for export, they cannot supply electricity to all regions of the country especially remote areas due to inadequate transmission and distribution infrastructure, which causes some population groups to lack modern energy services.

Then based on research conducted by C. Magazzino (2016) on $CO_2$ emissions, economic growth, and energy use in a Middle Eastern country. In his research, Maggazino used three versions of the DEA model oriented towards resource use by the OIC countries, finding that top performers were dominated by members of the fuel exporting countries (FEC) subgroups and underdeveloped OKI countries (LDC) caused by excellence in one or more indicators considered in the assessment (Cosimo Magazzino, 2016). In his research, he also found that Iran and Yemen are the lowest states in the utilization of resources.

The above literature gives the view that access to energy that is easily accessible, reliable, sustainable and modern for all can be achieved in certain ways that have been very well designed. The results of this study will provide information related to the level of energy access efficiency in 50 OKI countries.

## 3. RESEARCH METHODS

The method used in this research is Data Envelopment Analysis (DEA). DEA is a nonparametric method that uses a linear program model to calculate the ratio of output and input ratios for all units being compared. The advantage of using DEA is that this approach does not require explicit specifications of the form of the function and only requires a little structure to form its efficiency frontier. DEA is widely applied in performance evaluation and benchmarking in educational institutions, hospitals, financial institutions, production plans and others. The units used in DEA are referred to as DMUs. This technique can be used to find out how efficiently DMUs are used by utilizing existing equipment to produce maximum output. Weaknesses that may arise when using this method are self-identifiers and near self-identifiers. DEA was first developed by Farrel (1957) who measured the technical efficiency of one input and one output into multi-input and multi-output. In this study, the assumptions used are return to scale (VRS) variables and output oriented. As expressed by Johnes (2006) that the output-oriented model is an appropriate model for achieving economic efficiency. In this study, the data used to present the 7th SDGs sub-goals namely access to affordable, reliable, sustainable and modern energy for all and to measure the economic efficiency of the OIC countries is sourced from SESRIC. In detail the inputs and outputs used are stated in Table 1.

The analysis tool used in this study is DEAP 2.1 to measure the level of efficiency of all DMU member countries of the OIC during the period 2010-2017. Analysis for efficiency measurements will be carried out 2 times. The first calculation of efficiency with the CRS or CCR approach was introduced by Charnes et al. (1978). The second calculation of efficiency with the VRS or BCC approach was first introduced by Banker et al. (1984).

## 4. RESULTS AND DISCUSSION

This discussion will display the energy levels of 50 OIC Countries during the 2010-2017 period using the Data Envelopment Analysis (DEA) method. Input-output variable data in measuring energy

**Table 1: Grouping inputs and outputs**

| No. | Input | Output |
|---|---|---|
| 1 | Labor | (1) Ensure universal access to affordable, reliable and modern energy services |
| 2 | Capital | (2) Increase substantially the share of renewable energy in the global energy |
| 3 | | (3) Double the global rate of improvement in energy efficiency |

access levels in OIC countries based on SDGS number 2 obtained from the SESRIC (Statistical, Economic, and Social Research and Training Center for Islamic Countries). In addition to producing efficiency values, DEA can also produce potential improvement, or the level of improvement needed to achieve optimal levels of efficiency. So it can be seen which variables need to be improved. Based on the calculation of the DEA method, it assumes Variable Return to Scale (VRS) using MaxDea 6.1 software, it can be seen the efficiency level of 50 OKI Countries. The value/evel of energy access in OIC countries after data processing can be seen in the following Table 2:

Based on Table 2 above, it can be seen that the level of energy access in OIC countries fluctuates every year. The average value of energy access in the OIC countries as a whole is 0.82 where there are 17 countries that achieve maximum efficiency values every year, namely Albania, Bahrain, Brunei, Egypt, Iran, Iraq, Jordan, Kuwait, Malaysia, Morocco, Oman, Qatar, Saudi Arabia, Tunisia, Turkey, Turkmenistan and United Arab Emirates. The most inefficient countries are Mauritania, Afghanistan, Bangladesh and Djibouti with efficiency values below 0.5. The country of Djibouti is the country with the lowest energy access level with an average efficiency value of 0.32 in the period 2010-2017. From

**Table 2: OIC countries' energy access values**

| Country | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Mean | Rank |
|---|---|---|---|---|---|---|---|---|---|---|
| Albania | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.00 | 1 |
| Bahrain | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.00 | 1 |
| Brunei | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.00 | 1 |
| Egypt | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.00 | 1 |
| Iran | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.00 | 1 |
| Iraq | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.00 | 1 |
| Jordan | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.00 | 1 |
| Kuwait | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.00 | 1 |
| Malaysia | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.00 | 1 |
| Morocco | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.00 | 1 |
| Oman | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.00 | 1 |
| Qatar | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.00 | 1 |
| Saudi Arabia | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.00 | 1 |
| Tunisia | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.00 | 1 |
| Turkey | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.00 | 1 |
| Turkmenistan | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.00 | 1 |
| United Arab Emirates | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.00 | 1 |
| Algeria | 0.979 | 0.989 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.99 | 18 |
| Azerbaijan | 0.979 | 0.989 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.99 | 19 |
| Kazakhstan | 0.979 | 0.991 | 0.989 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.99 | 20 |
| Tajikistan | 1.000 | 1.000 | 1.000 | 1.000 | 0.978 | 0.999 | 0.978 | 1.000 | 0.99 | 21 |
| Guinea-Bissau | 1.000 | 0.999 | 1.000 | 0.997 | 0.991 | 0.990 | 0.985 | 0.985 | 0.99 | 22 |
| Cameroon | 1.000 | 1.000 | 0.994 | 0.983 | 0.972 | 0.999 | 1.000 | 1.000 | 0.99 | 23 |
| Gabon | 1.000 | 0.964 | 0.950 | 0.996 | 0.993 | 1.000 | 0.997 | 1.000 | 0.99 | 24 |
| Uganda | 1.000 | 0.994 | 0.996 | 0.991 | 0.985 | 0.975 | 0.968 | 0.971 | 0.99 | 25 |
| Chad | 0.907 | 0.954 | 0.954 | 0.953 | 0.956 | 0.959 | 0.960 | 0.959 | 0.95 | 26 |
| Uzbekistan | 0.999 | 1.000 | 0.995 | 0.952 | 0.934 | 0.905 | 0.895 | 0.895 | 0.95 | 27 |
| Mozambique | 0.983 | 1.000 | 0.999 | 1.000 | 0.943 | 0.949 | 0.832 | 0.825 | 0.94 | 28 |
| Togo | 1.000 | 0.984 | 0.960 | 0.938 | 0.926 | 0.911 | 0.903 | 0.897 | 0.94 | 29 |
| Nigeria | 0.967 | 0.963 | 0.972 | 0.921 | 0.901 | 0.920 | 0.922 | 0.926 | 0.94 | 30 |
| Niger | 0.938 | 0.898 | 0.844 | 0.914 | 0.907 | 0.916 | 0.925 | 0.923 | 0.91 | 31 |
| Sierra Leone | 0.920 | 0.878 | 0.857 | 0.844 | 0.824 | 0.871 | 0.858 | 0.861 | 0.86 | 32 |
| Guinea | 0.841 | 0.830 | 0.848 | 0.872 | 0.871 | 0.866 | 0.859 | 0.853 | 0.86 | 33 |
| Kyrgyzstan | 0.844 | 0.881 | 0.916 | 0.824 | 0.833 | 0.815 | 0.811 | 0.814 | 0.84 | 34 |
| Cote d'Ivoire | 0.895 | 1.000 | 0.890 | 0.868 | 0.849 | 0.747 | 0.728 | 0.721 | 0.84 | 35 |
| Burkina Faso | 0.896 | 0.884 | 0.851 | 0.831 | 0.828 | 0.804 | 0.799 | 0.774 | 0.83 | 36 |
| Guyana | 0.767 | 0.827 | 0.833 | 1.000 | 0.769 | 0.857 | 0.800 | 0.808 | 0.83 | 37 |
| Mali | 0.789 | 0.775 | 0.760 | 0.725 | 0.732 | 0.709 | 0.717 | 0.710 | 0.74 | 38 |
| Sudan | 0.701 | 0.731 | 0.741 | 0.764 | 0.770 | 0.754 | 0.709 | 0.725 | 0.74 | 39 |
| Pakistan | 0.639 | 0.644 | 0.649 | 0.680 | 0.699 | 0.653 | 0.666 | 0.657 | 0.66 | 40 |
| Indonesia | 0.493 | 0.532 | 0.588 | 0.636 | 0.684 | 0.721 | 0.772 | 0.807 | 0.65 | 41 |
| Yemen | 0.632 | 0.632 | 0.632 | 0.642 | 0.632 | 0.632 | 0.642 | 0.642 | 0.64 | 42 |
| Benin | 0.623 | 0.618 | 0.605 | 0.603 | 0.603 | 0.606 | 0.605 | 0.598 | 0.61 | 43 |
| Gambia | 0.616 | 0.611 | 0.608 | 0.636 | 0.584 | 0.580 | 0.577 | 0.570 | 0.60 | 44 |
| Senegal | 0.695 | 0.666 | 0.667 | 0.591 | 0.584 | 0.543 | 0.514 | 0.501 | 0.60 | 45 |
| Lebanon | 0.579 | 0.579 | 0.579 | 0.579 | 0.579 | 0.580 | 0.581 | 0.585 | 0.58 | 46 |
| Mauritania | 0.477 | 0.476 | 0.484 | 0.486 | 0.483 | 0.480 | 0.491 | 0.483 | 0.48 | 47 |
| Afghanistan | 0.343 | 0.487 | 0.436 | 0.431 | 0.449 | 0.430 | 0.527 | 0.513 | 0.45 | 48 |
| Bangladesh | 0.480 | 0.463 | 0.455 | 0.457 | 0.446 | 0.417 | 0.416 | 0.401 | 0.44 | 49 |
| Djibouti | 0.371 | 0.384 | 0.371 | 0.379 | 0.353 | 0.205 | 0.278 | 0.187 | 0.32 | 50 |
| Mean | 0.830 | 0.837 | 0.832 | 0.834 | 0.823 | 0.816 | 0.814 | 0.811 | 0.825 | |

Table 2 it was also found that there were 4 countries that were able to achieve an increase in the value of energy access efficiency for 7 consecutive years namely Indonesia, Iran, Malaysia, and Togo.

Energy access values can be classified into 4 groups based on their efficiency scale, namely Fully Eficient (100%), Highly Efficient (80-99%), Medium Efficient (50-80%), and Low Efficient (<50%) (Rusydiana & Nugroho, 2017). Of the total 400 DMUs analyzed, there were 184 DMUs which reached a maximum efficiency value of 100%, while the other 216 DMUs did not reach maximum efficiency (100%), with details; 80-99% efficiency as much as 107 DMU, 50-80% as much as 78 DMU, and efficiency values below 50% as much as 31 DMU, within a period of 8 years, from 2010 to 2017.

Next, in Table 3 will be shown the average efficiency of OIC countries by continent. This is intended to evaluate regional achievement of efficiency.

Table 3 shows that the highest energy level efficiency values obtained by European OIC countries were then followed by the countries of West Asia in the second position, which was superior to other Asian Regions, the third position was the central African region which was superior to other African regions, then followed by the region of Southeast Asia, North Africa, Central Asia, West Africa, East Africa and South Asia. Obtaining the value of the level of energy levels in each region has a different level of energy levels. Muslim countries in Europe are the regions with the highest energy levels. Then South Asia is a region that has the lowest energy efficiency level among OIC countries. Muslim countries are rich in energy reserves, including countries that are members of the OIC. Overall, OIC member countries have 63% of the world's crude oil and 62% of natural gas production. Saudi Arabia is the largest oil producing country with a total of 18% of total world oil reserves. Apart from Saudi Arabia, Iraq, Kuwait and the UAE are also the largest oil producers. Whereas coal, which has been the main energy source since the 18th century, OIC countries only have 5% of the total coal reserves in the world.

### 4.1. Level of Efficiency of Energy Access in OIC Countries

Energy efficiency rate values in 50 OKI countries will be measured using the Malmquist Index, with an output approach. The model used is BCC (Banker, Charnes, Chooper) which assumes Return Scale (VRS) Variables. It will also display Total Factor Productivity Change (tfpch), Technical Change (techch), Efficiency Change (effch), Pure Efficiency Change (pech) and Scale Change (sech) in each country.

Based on Table 4, the Total Factor Productivity (TFP) of 24 countries increased or remained constant and 26 countries experienced a decline at the end of the period. Based on the above results, Yemen is a country that has the highest rate of increase with a TFP value of 1.194. While the State of Egypt was the country that experienced the largest decline with a TFP value

**Table 3: Efficiency per region**

| DMU | Countries mean | Region's mean | Ranking | DMU | Countries mean | Region's mean | Ranking |
|---|---|---|---|---|---|---|---|
| Southeast Asia | | | | West Africa | | | |
| Brunei | 1 | 0.8847 | 4 | Benin | 0.61 | 0.7839 | 7 |
| Indonesia | 0.65 | | | Burkania Faso | 0.83 | | |
| Malaysia | 1 | | | Cote d'Ivoire | 0.84 | | |
| Central Asia | | | | Gambia | 0.6 | | |
| Uzbekistan | 0.95 | 0.7975 | 6 | Guinea | 0.86 | | |
| Tajikistan | 0.21 | | | Guinea-Bissau | 0.99 | | |
| Turkmenistan | 1 | | | Mali | 0.74 | | |
| Kazakhstan | 0.99 | | | Mauritania | 0.48 | | |
| Kyrgyzstan | 0.84 | | | Niger | 0.91 | | |
| South Asia | | | | Nigeria | 0.94 | | |
| Pakistan | 0.66 | 0.6387 | 9 | Senegal | 0.6 | | |
| Bangladesh | 0.44 | | | Sierra Leone | 0.86 | | |
| Afghanistan | 0.45 | | | Togo | 0.94 | | |
| Iran | 1 | | | East Africa | | | |
| West Asia/Middle East | | | | Djibouti | 0.32 | 0.7474 | 8 |
| Lebanon | 0.58 | 0.922 | 2 | Mozambique | 0.94 | | |
| Iraq | 1 | | | Uganda | 0.99 | | |
| Saudi Arabia | 1 | | | Central Africa | | | |
| UEA | 1 | | | Cameroon | 0.99 | 0.9403 | 3 |
| Bahrain | 1 | | | Chad | 0.95 | | |
| Qatar | 1 | | | Gabon | 0.99 | | |
| Oman | 1 | | | Guyana | 0.83 | | |
| Kuwait | 1 | | | North Africa | | | |
| Jordan | 1 | | | Algeria | 1 | 0.8596 | 5 |
| Yaman | 0.64 | | | Egypt | 1 | | |
| Europe | | | | Morocco | 0.62 | | |
| Albania | 1 | 1 | 1 | Sudan | 0.74 | | |
| Azerbaijan | 1 | | | Tunisia | 0.94 | | |
| Turkey | 1 | | | | | | |

**Table 4: Total factor productivity by country**

| Region | effch | techch | pech | sech | tfpch | Region | effch | techch | pech | sech | tfpch |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Southeast Asia | | | | | | West Africa | | | | | |
| Brunei | 0.967 | 0.965 | 1 | 0.967 | 0.933 | Benin | 0.961 | 0.956 | 1 | 0.961 | 0.919 |
| Indonesia | 1.021 | 0.966 | 0.999 | 1.022 | 0.987 | Burkania Faso | 0.978 | 0.876 | 1 | 0.978 | 0.856 |
| Malaysia | 1 | 0.979 | 1 | 1 | 0.979 | Cote d'Ivoire | 0.996 | 0.891 | 1 | 0.996 | 0.887 |
| Central Asia | | | | | | Gambia | 0.99 | 0.968 | 1 | 0.99 | 0.958 |
| Uzbekistan | 0.926 | 1.278 | 0.944 | 0.98 | 1.183 | Guinea | 0.989 | 0.925 | 1 | 0.989 | 0.915 |
| Tajikistan | 1.006 | 1.059 | 1.004 | 1.002 | 1.066 | Guinea-Bissau | 0.997 | 0.95 | 1 | 0.997 | 0.947 |
| Turkmenistan | 0.955 | 1.218 | 0.96 | 0.994 | 1.164 | Mali | 1.01 | 0.946 | 1 | 1.01 | 0.955 |
| Kazakhstan | 1.031 | 0.812 | 0.999 | 1.032 | 0.837 | Mauritania | 1.02 | 0.941 | 1 | 1.02 | 0.96 |
| Kyrgyzstan | 1 | 0.935 | 1 | 1 | 0.935 | Niger | 0.985 | 0.888 | 1 | 0.985 | 0.875 |
| South Asia | | | | | | Nigeria | 0.993 | 0.921 | 1 | 0.993 | 0.915 |
| Pakistan | 1.014 | 1.004 | 1 | 1.014 | 1.017 | Senegal | 1.021 | 1.087 | 0.999 | 1.022 | 1.111 |
| Bangladesh | 0.982 | 1.163 | 1.021 | 0.962 | 1.143 | Sierra Leone | 1.03 | 1.142 | 1 | 1.03 | 1.176 |
| Afghanistan | 1.035 | 1.062 | 1.024 | 1.011 | 1.1 | Togo | 0.93 | 1.077 | 0.941 | 0.988 | 1.001 |
| Iran | 1.027 | 0.888 | 1 | 1.028 | 0.912 | East Africa | | | | | |
| West Asia/Middle East | | | | | | Djibouti | 0.993 | 0.834 | 1 | 0.993 | 0.828 |
| Lebanon | 0.997 | 0.97 | 1 | 0.997 | 0.967 | | | | | | |
| Iraq | 1.027 | 0.898 | 0.999 | 1.029 | 0.922 | Mozambique | 1.032 | 1.045 | 1 | 1.032 | 1.078 |
| Saudi Arabia | 1.018 | 1.17 | 1 | 1.018 | 1.191 | Uganda | 0.948 | 1.147 | 0.961 | 0.986 | 1.087 |
| UEA | 0.97 | 1.183 | 0.97 | 1 | 1.148 | Central Africa | | | | | |
| Bahrain | 0.981 | 1.179 | 1.016 | 0.965 | 1.157 | Cameroon | 0.975 | 0.878 | 1 | 0.975 | 0.856 |
| Qatar | 1.015 | 1.163 | 1 | 1.015 | 1.18 | Chad | 1 | 0.894 | 1 | 1 | 0.894 |
| Oman | 1.013 | 0.98 | 1 | 1.013 | 0.993 | Gabon | 0.99 | 1.013 | 1 | 0.99 | 1.003 |
| Kuwait | 1.016 | 0.962 | 0.999 | 1.018 | 0.978 | Guyana | 1.016 | 0.966 | 1 | 1.016 | 0.981 |
| Jordan | 1.024 | 0.816 | 0.998 | 1.026 | 0.835 | North Africa | | | | | |
| Yaman | 0.936 | 1.276 | 0.946 | 0.99 | 1.194 | Algeria | 1 | 1.064 | 1 | 1 | 1.064 |
| Europe | | | | | | Egypt | 0.995 | 0.825 | 1 | 0.995 | 0.821 |
| Albania | 1.025 | 1.039 | 1 | 1.025 | 1.065 | Morocco | 1.027 | 1.057 | 1 | 1.027 | 1.086 |
| Azerbaijan | 0.978 | 1.054 | 1.012 | 0.966 | 1.031 | Sudan | 0.996 | 1.117 | 0.998 | 0.998 | 1.113 |
| Turkey | 0.954 | 1.211 | 0.95 | 1.004 | 1.156 | Tunisia | 0.949 | 1.077 | 0.946 | 1.003 | 1.022 |

of 0.821. During the study period, the most significant source of improvement came from Scale Change (sech). The source of the decline comes from Techical Change (tech), Efficiency Change (efch), and Pure Efficiency Change (pech).

OIC countries are grouped into four quadrants based on the category of technological change (TECH) and efficiency change (EFFCH), with high and low level categories. Tech and EFFCH numbers above 1 indicate the high category, while numbers below 1 indicate the low category (Table 5).

Quadrant 1 includes countries that have technological changes and high efficiency changes, so they can be considered as countries with high productivity. There are 11 countries included in this category, namely Pakistan, Afghanistan, Saudi Arabia, Qatar, Albania, Sierra Leone, Algeria, Morocco, Mozambique, Tajikistan, and Senegal.

Quadrant 2 includes countries that have high technological changes, but on the other hand have low efficiency changes. The collection of countries in this group can be considered as countries with low "catching up" abilities. The increase in the number of DMU countries in the second quadrant is a sign of the ineffectiveness of countries to produce efficiently (technical changes and the level of efficiency changes are classified into high and low categories based on their average values). The number of countries included in this quadrant is 13 countries.

Quadrant 3 includes groups of countries that have low technical changes, but on the other hand have relatively high efficiency changes. The collection of countries in quadrant 3 can be considered as a country with a low increase in production technology, but relatively able to achieve a relatively high increase in the value of efficiency. There are 13 countries included in this quadrant.

On the other hand, Quadrant 4 is a group of countries with changes in technology and low efficiency changes. The group of countries in this group can be considered as countries whose productivity growth rates are relatively stagnant due to the small value of TECH and EFFCH. There are 12 countries included in this quadrant.

Table 6 shows the level of productivity based on year to year. TFP score above number 1 describes an increase in productivity, while under one means a decrease. Based on Table 5, the productivity of OIC countries on average increased, but there was a decrease in 2012-2013, and 2016-2017. The rest has increased. The biggest decrease occurred in 2012-2013, while the biggest increase was in 2014-2015. Increased productivity is mainly due to Efficiency Change (effch). Positive changes in efficiency levels in the Efficiency Change (effch) column occurred in 2011-2012, 2012-2013, 2014-2015 and 2016-2017, while the rest had negative changes. This shows that Efficiency Change (effch) plays a role in the economic productivity of OIC countries.

## 5. DISCUSSION

Based on the results of the analysis above, it was found that the countries with the highest effectiveness points from 2010

**Table 5: Country quadrant malmquist index**

| Quadrant | Negara |
|---|---|
| Quadrant 1 | Pakistan |
| (High Technology, High Efficiency) | Afghanistan |
| | Saudi Arabia |
| | Qatar |
| | Albania |
| | Sierra Eone |
| | Algeria |
| | Morocco |
| | Mozambique |
| | Tajikistan |
| | Senegal |
| Quadrant 2 | Uzbekistan |
| (High Technology, Low Efficiency) | Turkmenistan |
| | UEA |
| | Bahrain |
| | Yaman |
| | Azerbaijan |
| | Turkey |
| | Togo |
| | Uganda |
| | Gabon |
| | Sudan |
| | Tunisia |
| | Bangladesh |
| Quadrant 3 | Indonesia |
| (Low Technology, High Efficiency) | Malaysia |
| | Kazakhstan |
| | Kyrgyzstan |
| | Iran |
| | Iraq |
| | Oman |
| | Kuwait |
| | Jordan |
| | Mali |
| | Mauritania |
| | Chad |
| | Guyana |
| Quadrant 4 | Brunei |
| (Low Technology, Low Efficiency) | Benin |
| | Burkania Faso |
| | Cote D'ivore |
| | Gambia |
| | Guinea |
| | Guinea-Bissau |
| | Niger |
| | Nigeria |
| | Djibouti |
| | Cameroon |
| | Egypt |
| | Lebanon |

**Table 6: Total factor productivity by year**

| Year | effch | techch | pech | sech | tfpch |
|---|---|---|---|---|---|
| 2010-2011 | 0.528 | 2.204 | 0.948 | 0.556 | 1.163 |
| 2011-2012 | 1.361 | 0.755 | 0.873 | 1.558 | 1.027 |
| 2012-2013 | 1.177 | 0.601 | 1.235 | 0.953 | 0.707 |
| 2013-2014 | 0.997 | 1.066 | 0.902 | 1.105 | 1.062 |
| 2014-2015 | 1.254 | 1.184 | 1.098 | 1.142 | 1.485 |
| 2015-2016 | 0.903 | 1.112 | 0.943 | 0.958 | 1.004 |
| 2016-2017 | 1.009 | 0.75 | 1.001 | 1.008 | 0.756 |
| mean | 0.994 | 1.007 | 0.994 | 1.001 | 1.002 |

to 2017 had 17 countries that received the maximum or perfect effectiveness score in the SDGs 8: Clean and Affordable Energy index assessment, namely point 1 for 8 years, namely Albania, Bahrain, Brunei, Egypt, Iran, Iraq, Jordan, Kuwait, Malaysia, Morocco, Oman, Qatar, Saudi Arabia, Tunisia, Turkey, Turkmenistan and United Arab Emirates.

Albania (European region) is one of the countries that achieved the maximum effectiveness value, which is point 1. Albania depends almost 100% on renewable energy sources to generate electricity, with 98.7% of its electricity generation coming from hydro, while energy saving in Albania reaches percentage of 22.48% of total energy consumption in 2015 (Sopian et al., 2011). In addition, Albania is an oil importer country with a percentage of 50-70%. Albania's effectiveness in managing clean and affordable energy gets the maximum results (Gabbasa et al., 2013).

Bahrain (Asia region) as a member of the GCC (Gulf Cooperation Council) that gets maximum energy effectiveness points. In Bahrain, however, high energy subsidies undermine renewable energy development, and domestic consumption reduces fuel export revenues. In 2016, Bahrain's per capita electricity consumption was 19,430 kWh making it the highest electricity consuming country among other GCC countries (Alarenan et al., 2019), however Bahrain also applies renewable energy to produce 700 MW and has the potential to process wind energy (Malik et al., 2019). Consumption of gas and oil in Bahrain also has no significant effect on $CO_2$ emissions (Shaari et al., 2020), even though it is not an energy exporting country, Bahrain generates its electricity from fossil fuel sources (Sopian et al., 2011), this shows that Bahrain can still manage energy for the people properly and effectively.

Egypt (Africa region) as the next country to get maximum effectiveness is a country that consumes a lot of wind energy and is rich in hydro energy (Anwar et al., 2017). Consumption of gas and oil in Egypt does have a significant effect on increasing $CO_2$ emissions which can be dangerous, but with the potential for wind and hydro, Egypt can develop renewable energy to replace oil and gas (Shaari et al., 2020), even Egypt has utilized heat. the earth, the sun, the tides and the waves for the country's power plants (Sopian et al., 2011), so that the effectiveness of energy use in Egypt can reach a maximum number in 8 years continuously.

The three countries above are some of the countries with the highest level of effectiveness that are located in different regions. The country with the lowest effectiveness value was Djibouti in the East African region with an effectiveness value of 0.32. Based on the world population in 2008, Djibouti has a population of <1 million people and a declining population growth (Gabbasa et al., 2013), besides that Djibouti is also one of the oil importing countries with a percentage of 50-70% and there is no research. which states that this country has a capacity in renewable energy, so that its energy consumption is greater than production and its effectiveness is low when compared to other OIC countries.

Furthermore, using the Malmquist index, the OIC countries' rankings are found based on their total points of change in productivity. The country that scored the highest in energy productivity was Yemen with a score of 1,194. Although there is an

increase in oil prices which has implications for decreasing Yemeni income (Anwar et al., 2017). In addition, there is geothermal energy development in Yemen, 47% of which is financed by the GEF (Global Environment Facility) with the aim of accelerating exploration and development of the use of geothermal energy (Sopian et al., 2011), Yemen's GDP per capita has always been ranked first compared to other OIC countries (Asim et al., 2011). The various potentials and advantages of Yemen seem to produce high productivity because it is well managed and even Yemen occupies quadrant 1 in the Malmquist quadrant which shows that this country has a high degree of change in effectiveness and technology.

The country with the worst productivity level was Egypt with a value of 0.821. Although in the ranking of effectiveness Egypt is an effective country, it is not in the level of productivity. Egypt is a non-OPEC oil exporting country, but what needs to be known is that Egypt has not been able to provide electricity supply to all its regions (Behboudi et al., 2013), especially remote areas due to inadequate transmission and distribution infrastructure (Gabbasa et al., 2013). In 2020, Egypt has just announced a 20% increase in renewable energy in power generation (Sopian et al., 2011), and as previously mentioned, consumption of gas and oil increases $CO_2$ emissions in Egypt (Shaari et al., 2020).

## 6. CONCLUSION

1. Energy level values in OIC countries fluctuate annually. The average value of energy levels in the OIC countries as a whole is 0.82 where there are 17 countries that achieve maximum efficiency values each year, namely Albania, Bahrain, Brunei, Egypt, Iran, Iraq, Jordan, Kuwait, Malaysia, Morocco, Oman, Qatar, Saudi Arabia, Tunisia, Turkey, Turkmenistan and United Arab Emirates. The most inefficient countries are Mauritania, Afghanistan, Bangladesh and Djibouti with efficiency values below 0.5.
2. Yemen is a country that has the highest rate of increase with a TFP value of 1.194. While the State of Egypt was the country that experienced the largest decline with a TFP value of 0.821. During the study period, the most significant source of improvement came from Scale Change (sech). The source of the decline comes from Techical Change (tech), Efficiency Change (efch), and Pure Efficiency Change (pech).
3. The highest energy level efficiency values obtained by European OIC countries then followed by the countries of the West Asian region in the second position, which is superior to other Asian Regions, the third position is the central African region which is superior to other African regions, then followed by Southeast Asia, North Africa, Central Asia, West Africa, East Africa and South Asia.
4. Countries that have reached a maximum energy level and high productivity are expected to be able to maintain government performance by maintaining the amount of input, and continue to work to increase output. So that the level of community welfare reflected in the SDGs indicators can be maintained, or even increased in the following year. As for countries that have not yet reached a good level of efficiency and productivity, they should be able to improve the performance of their governments by choosing the right strategy for the achievement of better SDGs.

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