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# Projections and Policy Scenarios to Meet Future Global Electric Energy Needs

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**ABSTRACT**

Projection and/or forecasting of future electricity production and consumption is needed to ensure its availability. The purpose of this study is to present empirical facts regarding global electricity production (supply) and consumption needs (demand) in the last 30 years (1993-2022). The second objective is to project and create policy scenarios to meet global electricity needs in the future, until 2052. Using a quantitative descriptive paradigm to explain empirical facts based on quantitative data. Data were collected from electricity production and consumption reports by Enerdata, and the European Commission during the period 1993-2022. Data analysis uses a Business-As-Usual (BAU) scenario model with the help of regression. It was found that global electricity consumption and production spread across Europe, CIS-Russia, North America, Latin America, Asia, the Pacific, Africa, and the Middle East during 1993-2022 are under each other, and show an increasing trend every year. Since 2003, Asia has had the largest electricity production and consumption. To meet global electricity needs until 2052, the policy scenario needed is the need for additional efforts from current production capacity. Asia is the largest, namely 370.05% or 12.33% per year.

**Keywords:** Business-As-Usual, Electric Energy, Production, Consumption, Policy Scenarios
**JEL Classifications:** Q01, Q41, Q42, Q47, Q48

## 1. INTRODUCTION

Energy is the main supply as a capacity to carry out all activities. Even the availability of energy is the capital and indicator of the progress and prosperity of a nation (Ayaviri-Nina et al., 2024; Marcus and Okezie, 2017; Aditya et al., 2016; and Caillé et al., 2007). The availability of energy is generated from various sources such as petroleum, coal, biomass, and electricity. The largest source of energy is produced from oil at 39% of total consumption, followed by coal at 37%, electricity at 13%, and biomass at 11% (Bp Energy Outlook, 2023). The electrical energy commonly used during generation uses natural gas, biomass, coal, sunlight, wind, river water, and sea tides (Phiri and Sesoai, 2024; Adi et al., 2024; Ibrahim et al., 2023; and Sharifzadeh et al., 2017). It can be said that electrical energy is a vital need for survival in a broad sense. In fact, there is almost no human need that is required without using electricity.

Electricity consumption continues to increase every year. Based on Enerdata's records (2024), in the last 30 years global electricity consumption has grown by almost 2.7%. Global electricity consumption during 2022 occurred more in the BRICS countries (Brazil, Russia, India, China, and South Africa), with the highest being China at around 7% or 1/3 of global consumption. Followed by India (6.7%), Brazil (3.2%), and CIS-Russia (1.4%) (Enerdata, 2024). These countries have strong economic growth followed by a high demand for electricity in all sectors. Meanwhile, South Africa tends to experience usage management by reducing consumption by around 4% (−4%) during 2023 (Enerdata, 2024).

Electricity consumption also increased in Middle Eastern countries by around 4.9%, especially in Saudi Arabia and Iran. Likewise, electricity consumption during 2023 in African countries, and Southeast Asia such as Indonesia, Thailand, and Vietnam grew by around 4% (Enerdata, 2024).

Different things are shown by OECD countries, decreasing electricity consumption (−3%), along with slowing growth. The United States decreased electricity consumption by around 1%, Japan decreased electricity consumption by around 1.9%, and South Korea by 1.3%. On the other hand, Canada and Mexico experienced an increase of 4.1% due to the pressure of economic growth (Enerdata, 2024).

The Enerdata (2024) report, states that in the 2018-2022 period, the largest electricity consumption needs (demand) are in the Asian region. Energy consumption for Asia in 2018 was around 10.905 TWh or around 46.46% of total global consumption (23,470 TWh). Followed by North America at 4,516 TWh (19.24%), Europe at around 3,382 TWh (14.41%), while the lowest was in the Pacific region at around 285 TWh (1.21%). Meanwhile, electricity consumption needs during 2022 for Asia increased to 12,868 TWh or increased by around 1,781 TWh with an average of 356 TWh/year. Likewise in North America, it increased to 4,612 TWh, and in the Pacific, it increased to 290 TWh. Only Europe showed a different trend, where energy demand decreased to 3,223 TWh or a decrease of around 32 TWh/year.

Power generation production is also greater in the Asian region, followed by North American countries, and the lowest in the Pacific region. Power generation production in the Asian region in 2018 was around 12,404 TWh, in 2022 it increased to 14,741 TWh or an increase of around 467 TWh/year. Countries in the North American region in 2018 produced 5,045 TWh of electricity, in 2022 it increased to 5,153 TWh or an increase of around 22 TWh/year. Meanwhile, in the Pacific region in 2018, it produced around 315 TWh of electricity, and in 2022 it became 324 TWh or an increase of around 2 TWh/year. The distribution of world electricity consumption and production in 2018 and 2022 is presented in Figure 1.

Electricity production data during 2018-2022 is still sufficient to meet the demand for electricity consumption. Behind that, something is interesting to see from its growth. Based on Enerdata (2024), global electricity consumption growth in the last 30 years has grown by 2.7%, while production growth has only been 2.5%. This means that there is a gap of around 0.2%. This figure then became one of the bases for experts' concerns regarding the sustainability of future energy, as conveyed by Andrae and Edler (2015), especially since the dependence on fossil fuels to generate electricity is very large (Adi et al., 2024; Redaputri, 2023; Ibrahim et al., 2023; and Kang et al., 2018).

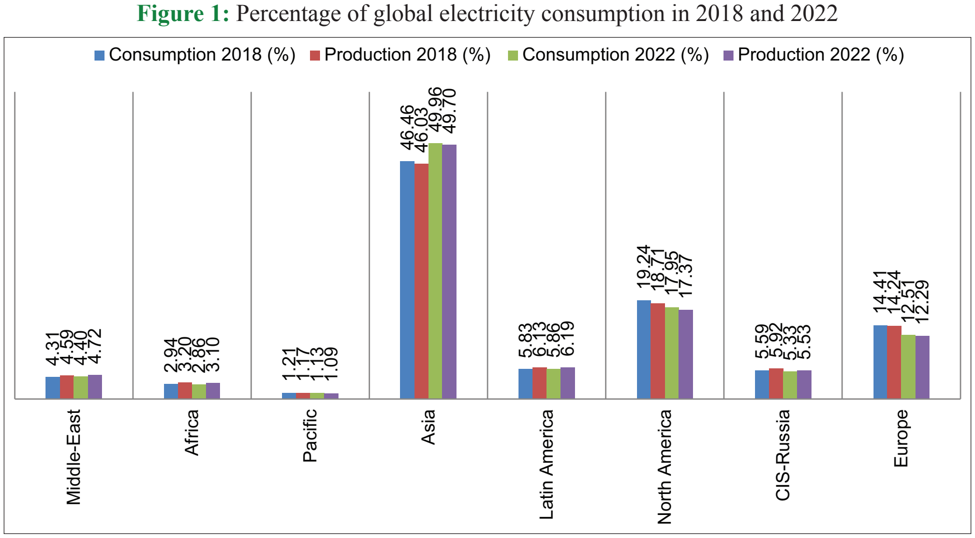
Furthermore, Andrae and Edler (2015) estimated that electricity use for the communications industry will increase by 51%, while reserves of electricity sources from petroleum (fossil) are expected to be increasingly depleted and will not be sufficient to meet future electricity needs (Grimaldo-Guerrero et al., 2021; and Maklad, 2014); On this basis, researchers such as Jiotsop-Foze et al. (2024); and Romadhoni and Akhmad (2020) suggest the need for further research on forecasting future electricity consumption based on production capacity.

The objectives of this study are twofold. First, to determine and analyze the magnitude of global production (supply) and consumption (demand) during the period 1993-2022. The second objective is to formulate a policy forecasting model to meet future electricity needs until 2052. The resulting policy scenario is an important finding of this study (novelty), which is useful, especially for policymakers and researchers.

## 2. LITERATURE REVIEW

According to Twidell and Weir (2005); Guney and Tepe (2017), energy is the ability to do work that can be in the form of heat, light, mechanics, chemistry, and electromagnetics. Energy

**Figure 1:** Percentage of global electricity consumption in 2018 and 2022



sources are anything that can produce energy through a process or directly. Energy is a need that cannot be separated from the lives of individuals or the lives of the nation and state. Energy is one of the important inputs for the production process, the more output produced, the higher the use of energy (Qurbani and Rafiqi, 2022; Rudenko and Tanasov, 2020; Yandri et al., 2018).

Quoted from Mitali et al. (2022); Zhao et al. (2022), that electrical energy is a form of electromagnetic energy that can be channeled using small electrically charged particles called electrons. Electrical energy is a type of secondary energy obtained from the conversion of primary energy after going through a process. Electrical energy is a type of basic energy source that is closely related to the national economy and people's livelihoods. Electricity is an important driver in driving economic and social development (Zhao et al., 2022).

Mthethwa et al. (2023) stated that the electric power system is a system consisting of components, namely generation, distribution, transmission, and loads that are interconnected to provide electricity needs. Electrical energy is generated by an electric generator driven by an electric turbine and directly connected to an electric generator. Electrical energy is an important source of energy for human life, both in industrial activities, commercial activities, and in daily household life (Prasetyowati et al., 2021; and Zohuri, 2021).

The development of electricity aims to ensure the availability of electricity in sufficient quantities (availability), good quality (acceptability), and reasonable prices (affordability). The provision of electricity is carried out by the central and regional governments and is prioritized for undeveloped, remote, and rural areas by utilizing the energy sources around them, especially renewable energy sources such as water, wind, and sun (Strielkowski et al., 2021).

Electrical energy can be obtained from various sources, namely:

1. Non-renewable energy sources. Can be (Rizzi et al., 2014; Phiri and Sesoai, 2024; Vine, 2008; and Manish et al., 2006): (a) Petroleum and natural gas. Petroleum and natural gas consist of a mixture of hydrogen and carbon elements (hydrocarbons) and other elements. Petroleum and natural gas come from organic sources that occur due to chemical changes; (b) Coal. Coal is a sedimentary rock that comes from organic materials and consists of various mixtures of carbon, hydrogen, oxygen, nitrogen, and several other impurities (Jie et al., 2021). Coal consists of several categories and subcategories based on its carbon calorific value. Lignite is the lowest coarse carbon solid, which passes through the levels of young coal, sub-bituminous coal, bituminous coal, and anthracite; and (c) Nuclear. Nuclear reactions are various interactions between free particles and atomic nuclei. Nuclear energy is another source of energy from mining, which can be developed through fission and fusion. Nuclear energy contains radioactive fuel which can cause deadly radiation hazards.
2. Renewable energy sources. Among them can be (Phiri and Sesoai, 2024; Ang et al., 2022; Ahmadi et al., 2022; Santika et al., 2019; Qazi et al., 2019; Ludin et al., 2018; Raheem et al., 2016; Kardooni et al., 2016; and Baños et al., 2011): (a) Sun. Solar energy or solar power comes from the heat component of the sun which comes from the radiation of hot light. Solar energy can be utilized in three ways. First, direct heating, namely sunlight directly emits heat to objects or mediums. Second, water heated by sunlight will be converted into electrical energy. Third, the photovoltaic method, namely energy from sunlight is directly converted into electrical energy; (b) Wind. Wind energy comes from the difference in temperature between cold air and hot air. Wind energy can be converted into mechanical energy that can produce work. Wind energy can be used for various activities such as driving water pumps for irrigation, sawing wood, grinding rice, and generating electricity (Bandoc et al., 2018); (c) Water. Water energy is generated from the movement of water. The movement of water can produce kinetic energy that can be converted into mechanical energy so that it can drive an electric generator. Hydropower is electrical energy that comes from the kinetic energy of water. There are three factors in determining the use of hydropower so that it can be a source of electricity generation, namely: the amount of water, the height of the waterfall that can be utilized, and the distance from the transmission network (Akuru et al., 2017); (d) Geothermal. Geothermal energy comes from heat energy in the earth's crust and comes from tectonic activity in the earth; and (e) Biomass. Biomass is an energy source that can be in the form of firewood and renewable agricultural waste. Biomass energy is useful in various sectors. Biomass energy can be used to generate energy by burning and converting it into other forms of energy such as methane gas or ethanol and biodiesel (Akuru et al., 2017).

## 3. METHODOLOGY

The research uses a quantitative descriptive paradigm, namely an explanation of empirical facts based on quantitative data (Dewi, 2021; Creswell and Creswell, 2017; Antwi and Hamza, 2015), namely global electricity production (supply) and consumption (demand) data. The research data was collected from electricity production and consumption reports by Enerdata (2023), International Energy Agenc, (2022), and the European Commission (2014). The data that was successfully collected was between the periods of 1993-2022.

The scope of the object analyzed is global electricity production and consumption divided into eight unions, namely Europe, CIS-Russia, North America, Latin America, Asia, Pacific, Africa, and Middle-East. The scope of this study is determined purposively according to the data division of the report by Enerdata.

The data collected through literature and documentation studies were then analyzed descriptively. Specifically for the formulation of the policy scenario model using *Business-As-Usual* (BAU) scenario analysis with the help of regression. BAU scenario analysis is often referred to as the basic energy forecast scenario. The Basic Scenario is an energy forecast scenario that is a continuation of historical developments or without any government policy intervention that can change historical behavior. The BAU scenario in the case of electrical energy has been tested by previous studies such as Alqurni and Hadiyanto (2023) and Nadia (2017).

The results of the BAU scenario are used as anticipation in the coming year regarding its availability (production) in the provision of future electrical energy, especially in 2052. The electrical energy policy scenario will emerge if the results of the BAU scenario are deemed insufficient and/or in other cases maintain the achievement position if it is sufficient.

# 4. RESULTS

## 4.1. Global Electricity Production and Consumption 1993-2022

According to data obtained from secondary sources (Enerdata, 2024, 2023; International Energy Agenc, 2022; and European Commission, 2014), global electricity consumption spread across Europe, CIS-Russia, North America, Latin America, Asia, Pacific, Africa, and Middle-East during 1993-2022 was in line with each other. This means that production (supply) and consumption (demand) are balanced or there is no gap. The amount of global electricity production and consumption for the period 1993-2022 is presented in Table 1. Infographics on the development of electricity production and consumption in Europe, CIS-Russia, North America, Latin America, Asia, Pacific, Africa, and Middle East are presented in Figure 2.

Judging from the trend, both the amount of production and consumption of electrical energy show an increase. Theoretically, this increase is in line with the increasing population growth, which is followed by an increase in the need for electrical energy (Ibrahim et al., 2023; Sharifzadeh et al., 2017; and Aditya et al., 2016).

For 30 years, the world's largest electricity production and consumption came from power plants located in North America and Asia. Interestingly, in the period 1993-2022, the highest electricity production was in North America, then entering 2003-2022 it shifted to Asia as the highest. Even between 2014 and 2020 the increase in production and consumption in Asia was almost twice that of production in North America, and the peak in 2021 and 2022 saw an increase of almost 3 times.

Over the past three decades, the largest share of global electricity production and consumption has been dominated by power plants located in North America and Asia. Notably, during the period from 1993 to 2022, North America initially led in electricity production, but from 2003 onward, Asia surpassed North America and became the largest producer. Between 2014 and 2020, the growth in electricity production and consumption in Asia was nearly twice that of North America, and by 2021–2022, Asia's production had surged to almost three times higher.

These trends, as presented in Table 1 and Figure 2, are supported by findings from Ibrahim et al. (2023) and Sharifzadeh et al. (2017), which indicate that many Asian countries most of which are classified as developing (excluding China) have actively pursued large-scale development of power plants. These energy

**Table 1: Global electricity production and consumption 1993-2022**

| Year | Total electricity production (TWh) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Europe | CIS-Russia | North America | Latin America | Asia | Pacific | Africa | Middle-East |
| 1993 | 2,558 | 1,066 | 3,505 | 581 | 2,511 | 179 | 290 | 276 |
| 1994 | 2,632 | 1,035 | 3,603 | 628 | 2,647 | 184 | 305 | 287 |
| 1995 | 2,716 | 995 | 3,696 | 643 | 2,803 | 189 | 319 | 308 |
| 1996 | 2,759 | 968 | 3,751 | 684 | 2,920 | 196 | 326 | 317 |
| 1997 | 2,818 | 944 | 3,851 | 722 | 2,999 | 206 | 335 | 343 |
| 1998 | 2,862 | 959 | 3,947 | 748 | 3,121 | 213 | 346 | 362 |
| 1999 | 2,952 | 986 | 4,044 | 789 | 3,333 | 218 | 361 | 379 |
| 2000 | 3,022 | 995 | 4,013 | 780 | 3,466 | 227 | 375 | 404 |
| 2001 | 3,057 | 997 | 4,107 | 803 | 3,679 | 238 | 404 | 429 |
| 2002 | 3,130 | 1,031 | 4,146 | 858 | 3,979 | 234 | 432 | 457 |
| 2003 | 3,186 | 1,058 | 4,201 | 903 | 4,362 | 240 | 456 | 481 |
| 2004 | 3,244 | 1,087 | 4,324 | 941 | 4,806 | 241 | 471 | 507 |
| 2005 | 3,302 | 1,138 | 4,321 | 986 | 5,238 | 246 | 494 | 539 |
| 2006 | 3,338 | 1,167 | 4,440 | 1,027 | 5,752 | 256 | 517 | 593 |
| 2007 | 3,369 | 1,196 | 4,417 | 1,067 | 5,965 | 256 | 519 | 638 |
| 2008 | 3,209 | 1,134 | 4,222 | 1,069 | 6,232 | 264 | 519 | 677 |
| 2009 | 3,358 | 1,200 | 4,395 | 1,134 | 6,851 | 268 | 555 | 743 |
| 2010 | 3,328 | 1,223 | 4,394 | 1,185 | 7,363 | 270 | 576 | 761 |
| 2011 | 3,340 | 1,249 | 4,336 | 1,246 | 7,712 | 268 | 596 | 793 |
| 2012 | 3,319 | 1,244 | 4,389 | 1,288 | 8,275 | 267 | 602 | 832 |
| 2013 | 3,256 | 1,248 | 4,418 | 1,312 | 8,696 | 268 | 620 | 882 |
| 2014 | 3,312 | 1,244 | 4,417 | 1,318 | 8,837 | 273 | 635 | 936 |
| 2015 | 3,361 | 1,266 | 4,439 | 1,334 | 9,243 | 277 | 668 | 952 |
| 2016 | 3,403 | 1,284 | 4,423 | 1,340 | 9,843 | 277 | 670 | 1,005 |
| 2017 | 3,417 | 1,320 | 4,588 | 1,386 | 10,423 | 281 | 703 | 999 |
| 2018 | 3,382 | 1,312 | 4,516 | 1,368 | 10,905 | 285 | 691 | 1,011 |
| 2019 | 3,271 | 1,289 | 4,443 | 1,375 | 11,033 | 285 | 690 | 1,014 |
| 2020 | 3,423 | 1,381 | 4,505 | 1,429 | 11,898 | 284 | 715 | 1,065 |
| 2021 | 3,321 | 1,352 | 4,661 | 1,465 | 12,205 | 289 | 732 | 1,082 |
| 2022 | 3,223 | 1,374 | 4,623 | 1,510 | 12,868 | 290 | 736 | 1,134 |

**Figure 2:** Global electricity production and consumption during the period 1993-2022

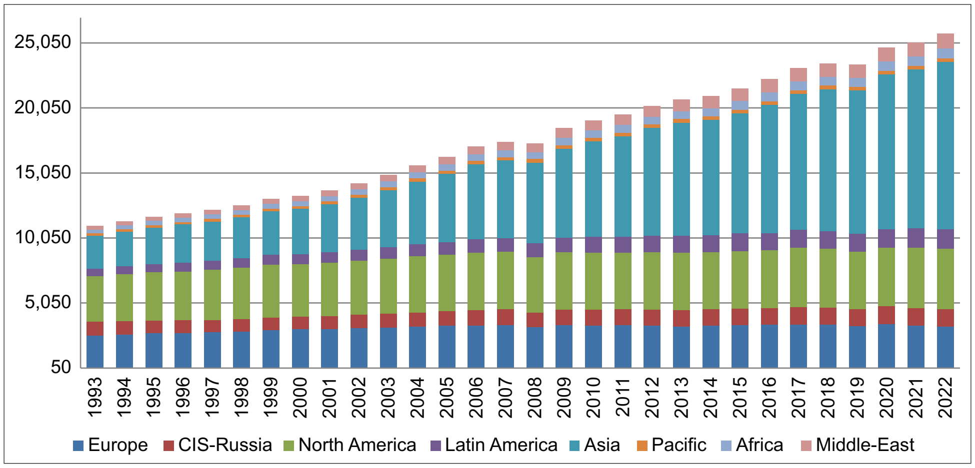
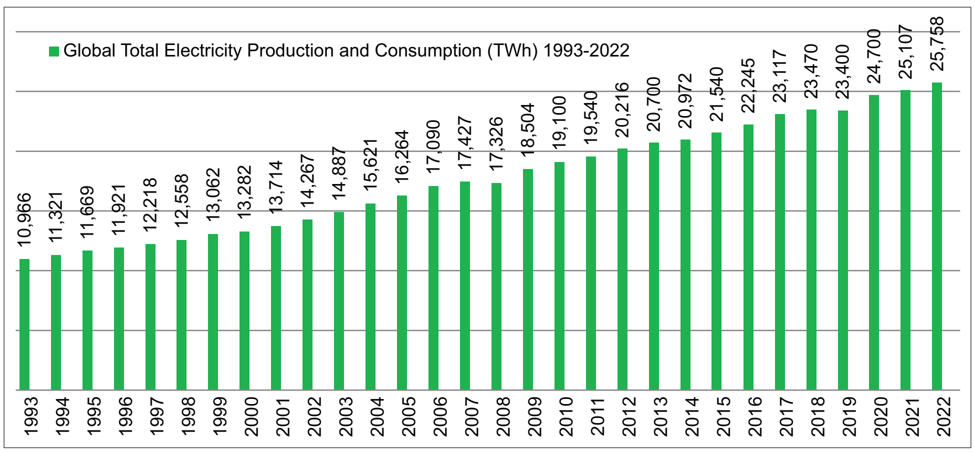



**Figure 3:** Global total electricity production and consumption (twh) 1993-2022



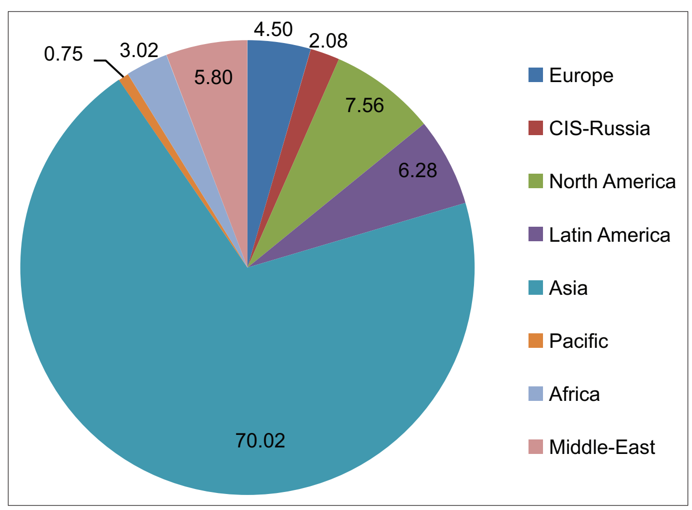

infrastructure projects are closely linked to efforts to accelerate industrialization and economic growth, as energy supply remains a key enabler for infrastructure expansion and manufacturing development.

Furthermore, in the last 30 years, global electricity production has increased by approximately 14,792 TWh, with an average annual growth of around 493.07 TWh or about 2.22%. This trend aligns with data from Enerdata (2024), which reports that over the past 32 years, global electricity consumption has grown at an average annual rate of approximately 2.5%. A comprehensive infographic illustrating the total electricity production and consumption between 1993 and 2022 is presented in Figure 3 below.

The highest percentage increase in electricity production and consumption during 1993-2022 occurred in the Asian region, and the lowest occurred in the Pacific region. As seen in Figure 4, there is a very significant difference, where the increase in production and consumption in the Asian region contributed around 70.02% of total global production. This figure was obtained from a total increase of 10,357 TWh or around 345 TWh/year with a total increase in production of around 29.98%.

North America increased by 7.56%, where from 1993 to 2022 it increased by 1.118 TWh or 37 TWh/year. Latin America increased

**Figure 4:** Percentage increase in global electricity production during 1993-2022




by around 6.28%, equivalent to 929 TWh or 31 TWh/year. The Middle East increased by around 5.80% equivalent to 858 TWh or 29 TWh/year.

Europe only experienced an increase of 4.50% equivalent to an increase of 665 TWh or 22 TWh/year. Africa increased by

**Table 2: Coefficients of electricity consumption projection analysis in Europe, CIS-Russia, North America, Latin America, Asia, Pacific, Africa, and the Middle East**

| Model | | Coefficients[a] | | | | |
|---|---|---|---|---|---|---|
| | | Unstandardized Coefficients | | Standardized Coefficients | t | Significant |
| | | B | Standard Error | Beta | | |
| Europe | (Constant) | −45553.662 | 5903.992 | | −7.716 | 0.000 |
| | Year | 24.267 | 2.941 | 0.842 | 8.251 | 0.000 |
| Dependent Variable: PL Europe | | | | | | |
| CIS-Russia | (Constant) | −28813.752 | 1829.679 | | −15.748 | 0.000 |
| | Year | 14.930 | 0.911 | 0.952 | 16.381 | 0.000 |
| Dependent Variable: PLRussia | | | | | | |
| North America | (Constant) | −60492.988 | 5262.907 | | −11.494 | 0.000 |
| | Year | 32.244 | 2.622 | 0.919 | 12.300 | 0.000 |
| Dependent Variable: PLNorth America | | | | | | |
| Latin America | (Constant) | −64611.876 | 1506.768 | | −42.881 | 0.000 |
| | Year | 32.715 | 0.751 | 0.993 | 43.588 | 0.000 |
| Dependent Variable: PLLatinAmerica | | | | | | |
| Asia | (Constant) | −736118.879 | 22569.405 | | −32.616 | 0.000 |
| | Year | 370.005 | 11.242 | 0.987 | 32.911 | 0.000 |
| Dependent Variable: PLAsia | | | | | | |
| Pacific | (Constant) | −7166.948 | 391.282 | | −18.317 | 0.000 |
| | Year | 3.694 | 0.195 | 0.963 | 18.953 | 0.000 |
| Dependent Variable: PLPacific | | | | | | |
| Africa | (Constant) | −32717.265 | 611.102 | | −53.538 | 0.000 |
| | Year | 16.558 | 0.304 | 0.995 | 54.393 | 0.000 |
| Dependent Variable: PLAfrica | | | | | | |
| Middle-East | (Constant) | −63781.731 | 1471.294 | | −43.351 | 0.000 |
| | Year | 32.107 | 0.733 | 0.993 | 43.809 | 0.000 |
| Dependent Variable: PL Middle East | | | | | | |

3.02% equivalent to 446 TWh or 15 TWh/year. CIS-Russia increased by about 2.08% equivalent to 308 TWh or an average of 10 TWh/year. Pacific increased by about 0.75% during 1993-2022 equivalent to 111 TWh or an average increase of 4 TWh/year.

## 4.2. Projection and Policy Scenario for Fulfilling Electricity Needs in 2052

The database used is historical data for the last 30 years, namely 1993-2022. The basis for forecasting or projecting electricity consumption and policy scenarios refers to the results of the Business-As-Usual (BAU) scenario analysis with the help of regression equations. One of the bases for determining the amount of policy intervention refers to the coefficient table as presented in Table 2 below.

### *4.2.1. Europe*

Based on the results of the BAU analysis as presented in Figure 5, it is known that in the next 5 years, precisely in 2027, electricity consumption in Europe is expected to increase to reach 3,336 TWh. Then it will increase quite significantly in 2042 which is projected to reach 4,000 TWh. After that, it slowly shows an increase in consumption until 2052 to 4,275 TWh.

To offset the increase in energy needs until 2052, the BAU analysis policy scenario requires additional efforts. The assumption is that the analysis conducted assumes that there is no increase in production capacity, so the BAU scenario model is considered inadequate. The additional effort required is that there must be a policy to increase electricity production capacity. As the results of the BAU analysis and regression tests as presented in Table 2, the policy to increase electricity production in Europe until 2052 is around 24.27%. This means that countries in Europe must increase production capacity by 24.27% to ensure electricity availability until 2052. In the short term, this can be done by increasing annual production capacity by around 0.81%.

As seen in Figure 5, with additional efforts to increase electricity production by around 0.81%/year, it can meet the electricity demand from the additional efforts. For example, the projection of electricity demand in 2027 is 3,636 TWh, with additional efforts to produce electricity of around 0.81%, it can produce around 3,668 TWh. The same pattern consistently occurs until 2052, when the BAU analysis projects electricity demand of around 4,242 TWh, while the results of the additional effort scenario are at 4,500 TWh.

### *4.2.2. CIS-Russia*

As seen in Figure 6, the projection of electricity consumption needs in CIS-Russia in 2023-2042 shows a quite significant curve. As seen, electricity consumption needs in 2023 are projected to be around 1,390 TWh and in 2042 to be 1,673 TWh. Furthermore, entering 2043 and beyond, the increase in electricity consumption seems to slow down, reaching a peak in 2052 at around 1,844 TWh.

The curve of increasing electricity demand in CIS-Russia looks similar to the increase in Europe. Likewise, policies in efforts to meet future electricity needs require additional efforts. The difference is seen in the amount of additional effort.

Additional effort policies are needed if energy production is not increased, then according to the BAU analysis, it is not sufficient. As seen in Table 2, CIS-Russia must formulate policies with

**Figure 5:** BAU analysis projection model of European electricity consumption needs until 2052

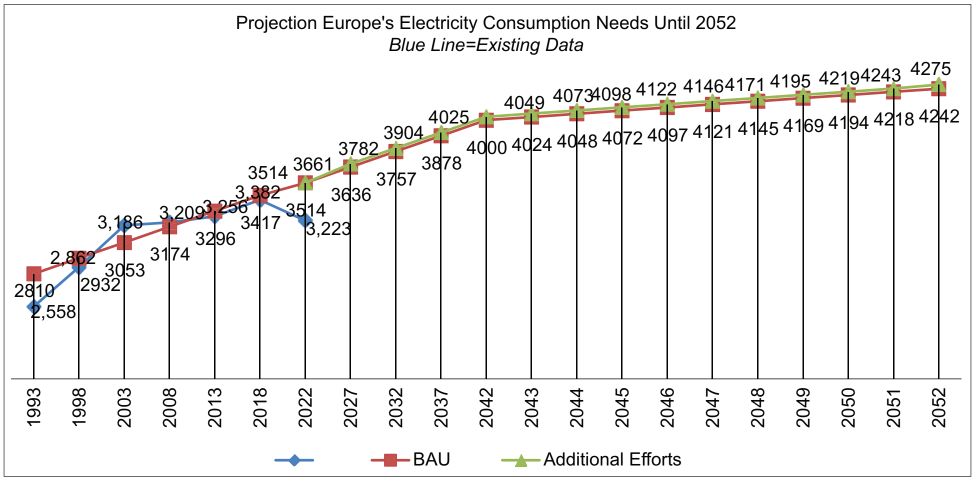
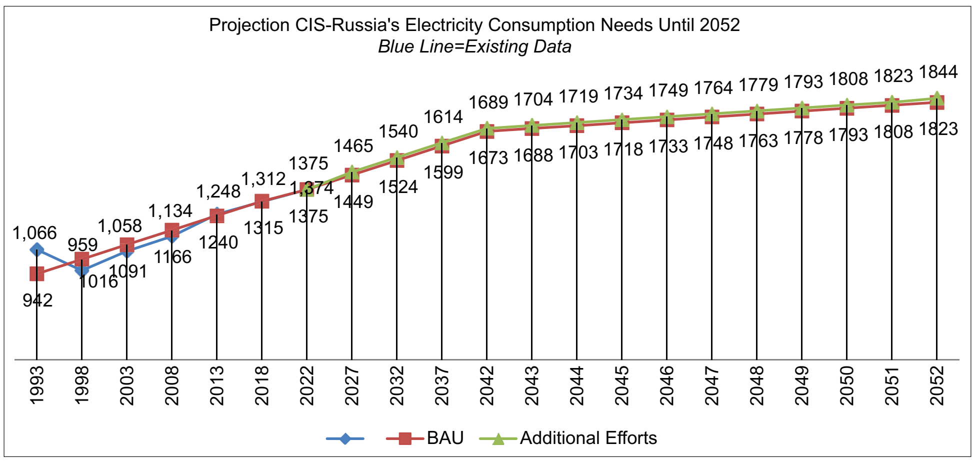



**Figure 6:** BAU analysis projection model of CIS-Russia electricity consumption needs until 2052




additional production efforts to meet future electricity needs in 2052 by 14.93% or around 0.50%/year.

As shown in Figure 6, the policy of additional electricity production efforts in CIS-Russia began to meet the demand for electricity consumption in 2024-2052. It can be seen that the BAU projection of electricity needs in 2024 is around 1,405 TWh, while the projection of additional electricity efforts is around 1,425 TWh. The same pattern occurs until 2052, the BAU projection of electricity consumption needs is 1,823 TWh, while the projection of additional efforts is around 1,844 TWh.

### *4.2.3. North America*

Electricity consumption and production in North American countries is the second largest after Asia. During the observation period and BAU projection analysis as presented in Figure 7, it shows a significant increase, the peak is estimated to occur in 2042. The BAU projection results for electricity needs in 2042 are around 5,349 TWh or an increase of around 645 TWH since 2022.

In 2043-2052, there will still be an increase in electricity demand, but not as large as the previous period. The demand projection from the BAU analysis in 2052 is 5,672 TWh or an increase of 323 TWh since 2043, smaller than the increase in the previous period.

Interestingly, the electricity demand forecasting model in North America appears similar to the pattern in Europe and CIS-Russia. This fact suggests that the fulfillment of electricity needs for the period 2023-2042 needs attention because at that time it showed a significant increase. The practical consequence is that every country in North America (including Europe and CIS-Russia) must try to balance demand (needs) with electricity production capacity early on. If ignored, it will certainly have worse consequences, until 2052.

The results of this analysis indicate the need for additional efforts to offset the trend of increasing electricity demand in the future. As shown in Table 2, additional policy efforts are needed to meet electricity needs in the North American region until 2052 by 32.24% or around 1.07% each year. The policy scenario carried out with additional electricity production efforts has been proven to be able to meet, or even exceed, the projections of BAU analysis needs. On this basis, each country in the North American region must plan for additional electricity production efforts. Increasing production capacity is a short-term option, but what is much more important is preparing policies and infrastructure for the use of renewable energy sources.

### *4.2.4. Latin America*

As presented in Figure 8, the consumption and production of electricity in the Latin American region in 2052 is projected to

**Figure 7:** BAU analysis projection model of North America electricity consumption needs until 2052

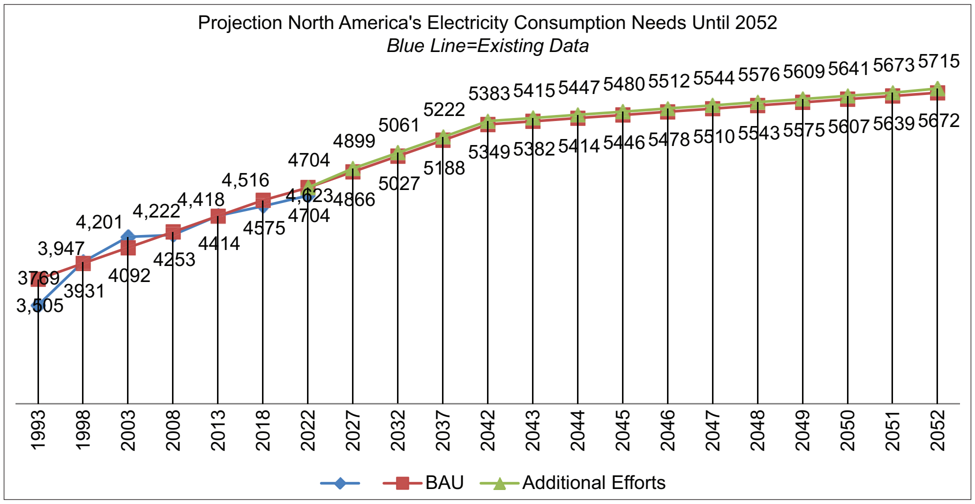
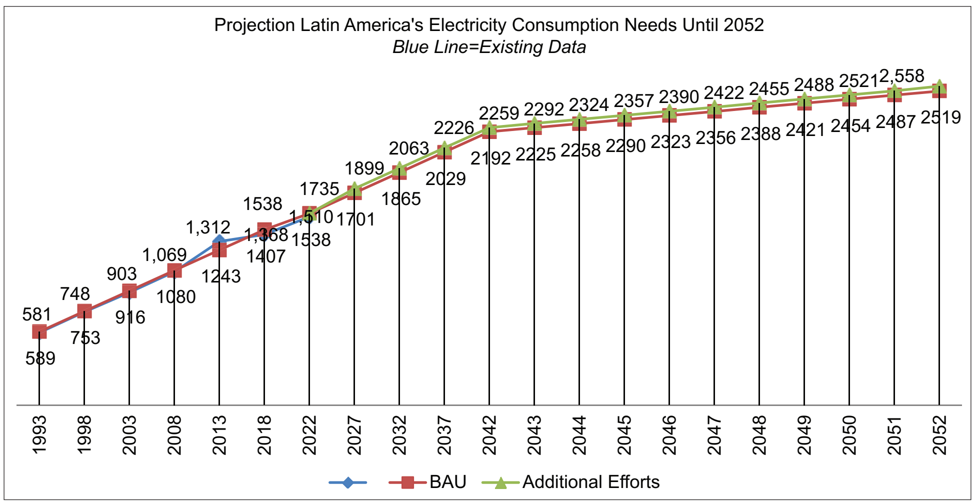



**Figure 8:** BAU analysis projection model of Latin America electricity consumption needs until 2052




increase by 63%. This can be seen from the results of the BAU analysis, that the amount of electricity production in 2022 is around 1,538-2,519 TWh in 2052.

The results of the BAU analysis, a significant increase will occur in the 2040s. This means that in this period there will be a significant increase in the spike, and after that, it tends to experience a slowing curve in the number of electricity consumption.

According to the results of the BAU analysis forecast, efforts to offset the increasing need for electrical energy in Latin America until 2052 require additional policy efforts, namely increasing production capacity. This additional effort as a future policy scenario, if ignored, can have broad consequences that are very detrimental in all aspects.

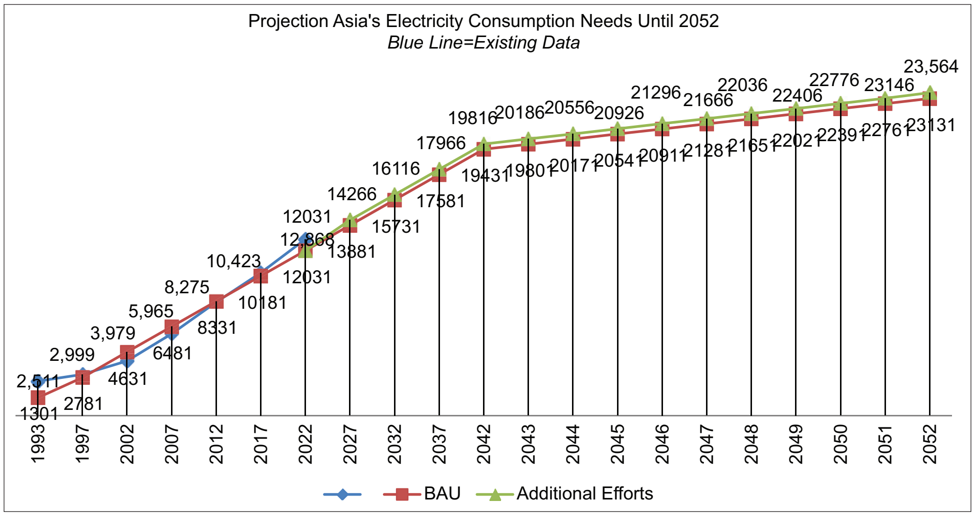
The results of the BAU analysis and regression tests presented in Table 2 show that the policy scenario for increasing electricity production in the Latin American region until 2052 is 32.72% or around 1.09%/year. As seen in Figure 8, the policy scenario with an effort to increase production capacity of around 1.09% per year, then the magnitude of the projected results of electricity consumption during 2023-2052 is in line with the magnitude of the increase in electricity consumption resulting from additional efforts. This means that by increasing production capacity, there is a guarantee of the continuity of future electricity needs.

#### *4.2.5. Asia*

Electricity consumption in Asian countries is the largest, contributing almost 70% of total global consumption. The results of the BAU analysis show that there was an increase in consumption between 1993 and 2022 of around 80%. This can be seen from the electricity consumption in 1993 of 1,301 TWH, in 2022 it became 12,031 TWh. Until 2052, electricity consumption in Asia is projected to be 23,131 TWh or an increase of around 51% from production in 2022. The results of the forecast of electricity needs in Asia until 2025 are presented in Figure 9 below.

To offset the increase in electricity needs in Asia by 2052 by around 51%, additional efforts are needed that are greater than the current conditions. As the results of the analysis of additional efforts presented in Table 2, the long-term policy scenario to meet electricity needs in Asia is an increase in electricity production

**Figure 9:** BAU analysis projection model of Asia electricity consumption needs until 2052




capacity of around 370% by 2052, or the short term an additional capacity of around 12.33% per year is needed.

Indeed, the figure is quite large when compared to other regions analyzed. With the BAU assumption, the number is the result of increased consumption needs from 1993 to 2022. On this basis, efforts to increase production can balance the rate of consumption demand. As seen in Figure 9, the rate of increase in additional electricity production until 2052 is in line with the rate of increase in consumption due to additional efforts. This means that with additional efforts of at least 12.33%, future electricity needs can be guaranteed.

### *4.2.6. Pacific*

Electricity consumption and production in Pacific countries only contribute 0.75% of total global consumption. However, the trend of increasing electricity consumption until 2052 is quite significant. According to the results of the BAU analysis as presented in Figure 10, electricity consumption in 2022 is around 302 TWh, or an increase of 35% from consumption in 1993. Meanwhile, the projected results of electricity consumption in 2052 are around 413 TWh or an increase of around 25% from consumption in 2023.

In order to maintain the electricity needs in the Pacific region to be met until 2052, a policy scenario is needed through additional efforts. The results of the BAU scenario analysis as presented in Table 2 show that the additional efforts in question are an increase in production capacity of around 3.69% or around 0.12% per year. This means that countries in the Pacific must increase their previous electricity production capacity by around 0.12% per year to ensure electricity fulfillment until 2052. With this assumption, the results of the BAU projection between the rate of increase in electricity consumption needs and the rate of increase in consumption resulting from additional efforts run in the same direction (Figure 10).

### *4.2.7. Africa*

African countries consume and produce electricity around 3.02% of total global production. The results of the BAU projection analysis, between 1993 and 2022 there was an increase in energy consumption of more than 35%. Then there was a significant increase during the period 2023-2052 of more than 60%. As seen in Figure 11, the BAU analysis projects the amount of electricity consumption to be around 780 TWh, then in 2052 it increased to 1,260 TWh. With the increasing need for electricity consumption from 2023 to 2052, African countries must increase their production capacity from before. This is based on the results of the BAU analysis, namely the need for additional efforts. This step is a policy scenario that must be taken by African countries to ensure the availability of electricity demand in the future.

Referring to the data in Table 2, the scenario of additional efforts to meet the electricity needs in Africa until 2052 is to increase electricity production capacity by 16.56% or around 0.55% per year. Evidently, with this effort, the projected rate of increase in electricity production between 2023 and 2052 is in line with the rate of increase in the additional effort projection. With this effort, there is a guarantee of meeting future energy needs in Africa.

### *4.2.8. Middle-East*

Electricity production and consumption in Middle Eastern countries account for about 5.80% of total global consumption. This amount is the fourth largest after North America, Latin America, and Asia. The results of the BAU projection analysis, electricity consumption in 2023 is around 1,171 TWh, while electricity consumption in 2051 is projected to be around 2,102 TWh.

This means that there is an increase in electricity consumption between the 2023 and 2052 period of more than 50%. This figure is higher than the increase in electricity consumption during the 1993-2022 period of 18%.

**Figure 10:** BAU analysis projection model of Pacific electricity consumption needs until 2052

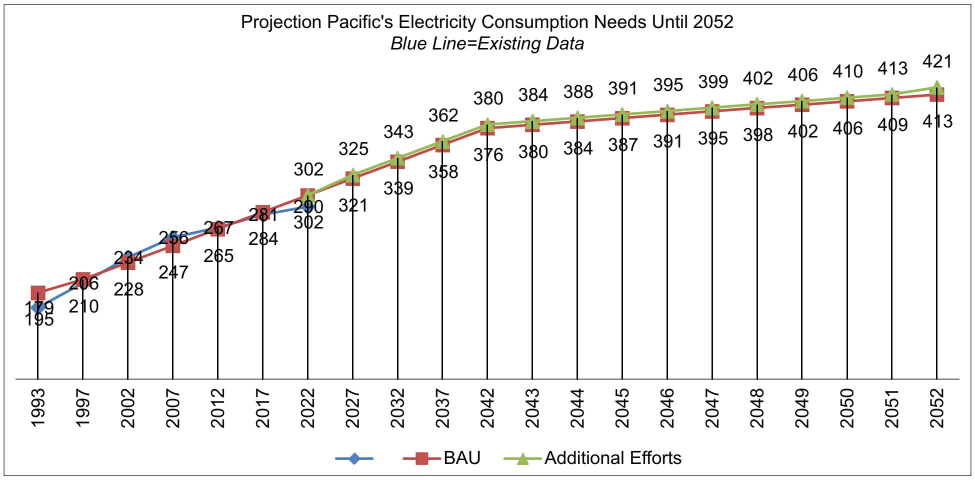



**Figure 11:** BAU analysis projection model of Africa electricity consumption needs until 2052

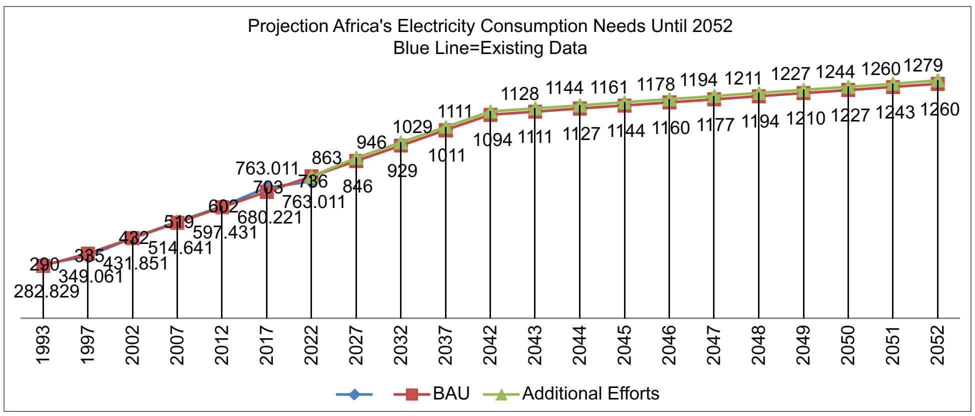
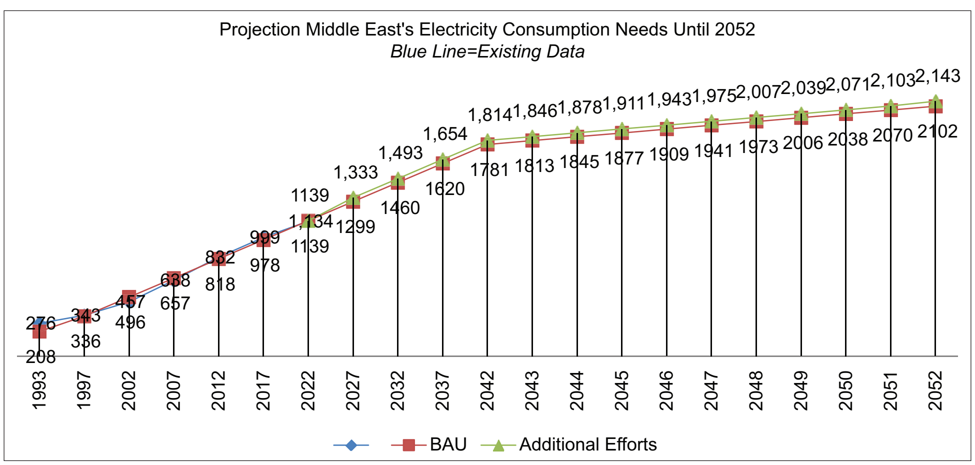



**Figure 12:** BAU analysis projection model of Middle-East electricity consumption needs until 2052




Based on the data (Figure 12), if there is no effort to increase production, there will be insufficiency. This effort is a policy scenario that must be carried out by countries in the Middle East to meet future electricity consumption demands.

The results of the BAU scenario analysis as presented in Table 2, the magnitude of the additional policy effort scenario that must be carried out to meet energy needs in the Middle-East until 2052 is around 32.11% or at least 1.07% per year. It is proven that with these efforts there is a balance between the curve of the rate of increase in projected consumption and the magnitude of additional efforts.

## 5. CONCLUSION

Global electricity consumption spread across Europe, CIS-Russia, North America, Latin America, Asia, Pacific, Africa, and Middle-East during 1993-2022 is in line, meaning that production and consumption are balanced. The amount of electricity production and consumption increases every year. During the period 1993-2022, the highest electricity production was in North America, entering 2003-2022, shifting to Asia as the highest, increasing more than twofold.

The results of the *Business-As-Usual* scenario analysis show that meeting global electricity needs (Europe, CIS-Russia, North America, Latin America, Asia, Pacific, Africa, and the Middle East) requires additional efforts from current production capacity. This step is a policy scenario to meet electricity consumption needs until 2052. The biggest challenge in meeting electricity needs until 2052 is in Asia, which is 370.05% of current capacity. Other quite challenging efforts are in Latin America, North America, and the Middle East, each of which is adding capacity of around 32% of current capacity. Europe must increase its electricity production capacity to meet electricity needs until 2052 by 24.27%; then Africa by 16.56%; CIS-Russia by 14.93%; and the Pacific by 3.69%.

As a recommendation, considering the findings of this study, further discussion is still needed, especially when compared to the availability of resources or raw materials for power plants. Therefore, it would be very interesting to see the results of the electricity demand forecasting analysis in relation to the availability of raw materials. It is recommended to use a stronger database (time series).

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