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Analysis of the Global/Regional Energy Situation to Overcome the Challenges to Implementation of Bangladesh Vision 2041

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Abstract: Primary energy in Bangladesh is moving towards import dependence day by day. But to ensure energy security and inclusive development we need to make the right decisions about fuel mix. Energy and Mineral Resources Division is concerned about future energy security, primary energy trends, energy mixes and sustainable development in the energy and power sectors. In our country, complete gas transmission and distribution pipelines, metering stations should be under proper online monitoring system (such as SCADA) for transparency development, corruption reduction and efficient management. Development of LNG grid pipeline is becoming an important issue for taking full power from FSRU. Private (local) investment in the national grid pipeline can be considered with the concerned stakeholders. Incentives for voluntary energy efficiency and conservation action planning for industries e.g., tax incentives and low interest loans for industrial energy efficiency systems] should be considered. Promote combined heat and energy (CHP, also known as instinct) through taxes. In contrast to energy efficiency standards and labeling for passenger vehicles [through tax incentives for EVs and low-interest loans, etc.], according to the Paris Agreement, global warming should not exceed 2 degrees in the next century. To reduce carbon emissions, clean and modern energy should play an important role for a healthy environment but it needs to be affordable. Hydrogen fuel is an alternative and sustainable alternative that addresses renewable energy to reduce carbon emissions and greenhouse gases (GHG). Collecting microorganisms from our adequate marine sectors (seas, rivers and canals) is a new possibility for Bangladesh to ensure a blue economy. Research work on renewable energy should be industrialized (tagged with government or non-government organizations) for a sustainable energy solution. The energy and power sectors need to be properly addressed by identifying cyber risks and vulnerabilities. Continuous evaluation and development of existing networking systems is required to ensure efficient and efficient operation in the energy and power industries. Each stakeholder needs to work together with appropriate coordination to ensure technology transfer. Policy makers, industry and academics should cooperate and collaborate to develop a sustainable energy pricing and subsidy for the inclusive development of the country.

Keywords: World Energy, Energy Economic, Energy Consumption, Energy Mix

1. Introduction

Energy plays an important role in the economic growth of a country. Energy improves the efficiency and productivity of the country and plays a very important role in the individual and household life. The role of energy in economic development is undeniable. It is one of the driving forces of development. It is consumed to meet energy requirement for subsistence (e.g. cooking, lighting, room heating etc. at household level) needs and for productive activities (e.g. agriculture, industry, transport, commercial etc.).

Bangladesh is facing a severe energy crisis as a result of slow growth in energy supply while energy demand needs to increase reasonably to achieve high economic growth. Therefore, to implement the Government's Vision 2041 to sustainably increase energy demand, the Planning Commission has prepared a Bangladesh Perspective Plan 2041 (PP2041): a strategic statement of the Government's

development vision, mission and goals to achieve a prosperous Bangladesh with a political base aimed at making Vision 2041 a reality. Economic freedom is a reality that will make it a developing income country by 2041 [1].

An important element in implementing energy security is vision. The plan aims to build an integrated and developed energy sector with a diversified fuel mix that will drive a sustainable local and national economy while achieving global competitiveness in all sectors by 2041. The plan will ensure quick and timely decisions to steadily encourage a greater role of the private sector in the energy sector; Ensuring transparent governance of energy-related government institutions; improving human capital development; Supporting the development of the energy sector through physical and systemic frameworks; and contributing to the protection and enhancement of the natural environment. It will also promote renewable energy, such as solar and biogas; and will ensure access to power and energy for all.

Bangladesh's economic development depends on reliable energy supply. Bangladesh is on the way to becoming a developing country, facing a number of major challenges, including poverty, political instability, overpopulation and the risk of climate change. However, Bangladesh has been praised by the international community for its significant progress in human development indicators. Through various government-led programs and NGO-led social programmes, the country is improving living standards and life expectancy, promoting education and women's empowerment, curbing population growth, achieving self-sufficiency in food production and building healthcare infrastructure. The country is undergoing rapid industrialization with globally competitive industries in textiles, shipbuilding and pharmaceuticals. International community has identified Bangladesh as the next emerging economy. Behind all energy is playing an important role in all economic activities.

2. Present Energy Scenario of Bangladesh

Bangladesh is the most energy deficient country in the world. It is located in the Asia Pacific region. Almighty Allah has blessed this sparsely populated country with significant potential of primary energy resources. This includes traditional domestic fossil fuels such as natural gas, coal and small amounts of oil and significant potential for undiscovered hydrocarbons in on shore and off shore. Non-conventional energies such as CBM, shale gas and synthetic gas such as UCG also have potential. Solar energy, water and wind have huge potential as renewable energy.

Due to the lack of proper initiatives in the energy sector during the previous government, the current energy crisis has become acute. As a result, the overall growth of other production sectors including industry and power generation is being disrupted. To overcome the country's stagnant situation, the government is working to ensure energy supply to accelerate the pace of economic development and to achieve this goal, short-term, medium-term and long-term plans have been adopted for domestic primary fuel exploration, development and production. Considering the shortage of domestic commercial energy such as gas and coal, a multi-pronged approach has been taken to import various commercial energy: (i) electricity, (ii) coal, (iii) petroleum through pipelines (iv) natural gas through pipelines, (v) natural Gas as LNG, vi) Liquefied Petroleum Gas (LPG).

Table 1. *Bangladesh Energy Mix calculation for 2020-21 (MTOE) [2].*

Name	MTOE
Oil (Crude + Refined)	8.81
LPG	1.44
Natural Gas	20.70
LNG	5.01
Coal (Imported)	4.27
Coal (Local)	0.48
RE (Hydro)	0.17
RE (Solar and wind)	0.40
Electricity (Imported)	0.86
Total Commercial	42.14
Biomass	14.58
Total primary	56.72

Natural gas is currently the main source of primary energy supply followed by the biomass. A share of primary energy by different fuel sources in Bangladesh is presented in the Figure 1.

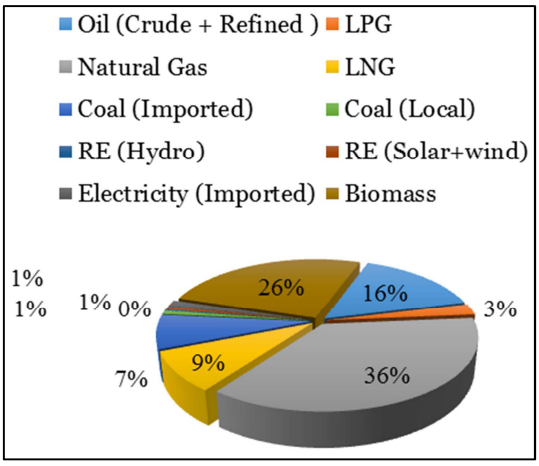


Figure 1. *Share of Total Primary Energy (2020-21) in Bangladesh [2].*

Bangladesh's known commercial energy resources include indigenous natural gas, coal, imported oil, imported electricity, and renewable energy hydro and solar power. Biomass accounts for about 26% of primary energy and the remaining 74% is met by commercial energy. Natural gas accounts for about 69%, petroleum products contribute 23%, coal 6% and renewable energy 1% of the commercial energy. The total primary energy supply in 2020-21 was 56.72 Mtoe. The energy mix (Figure 1 and Figure 2) is heavily dependent on domestic resources, natural gas. The reserve of which is rapidly decreasing. Then petroleum products which are mostly imported. Coal's contribution is very low (only 8%), which is the most important for exploration.

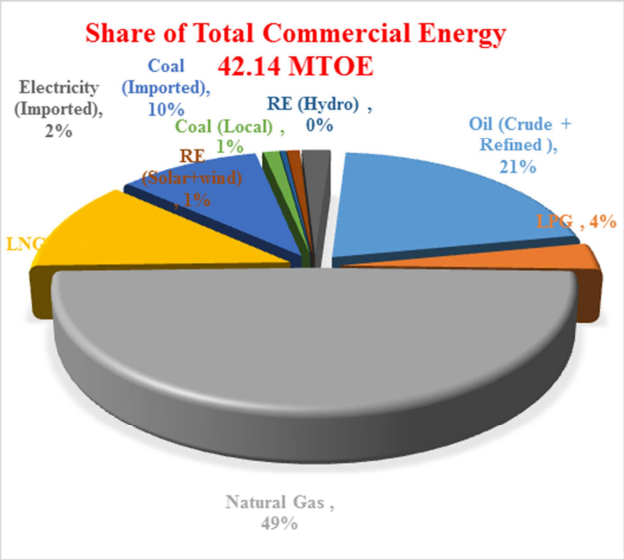


Figure 2. *Share of Total Commercial Energy (2020-21) in Bangladesh [2].*

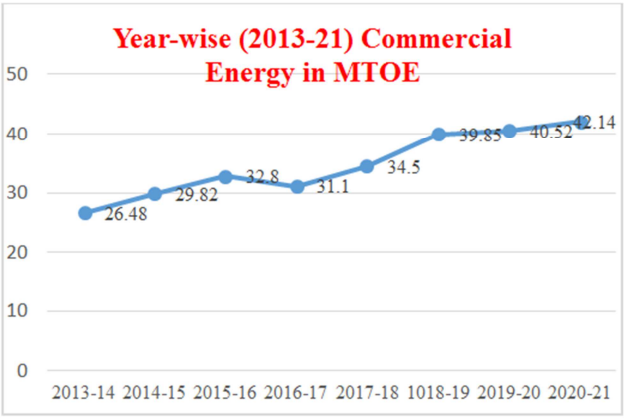


Figure 3. *Year-wise (2013-21) Commercial Energy in MTOE [2].*

3. World Energy Scenario

Global energy consumption refers to the total energy used by human civilization. Typically, energy is measured per year. It includes every source of energy applied to human endeavor in every industrial and technological sector across every country. Global energy supply and Consumption is the global production and preparation of energy, power generation, energy transport and energy consumption. It is a fundamental part of economic activity. Energy production is 80% fossil [14]. Half of it is produced by China, the United States and the Arab states of the Persian Gulf. The Gulf states and Russia export most of their production to the European Union and China, respectively, which do not produce enough energy to meet demand. Energy production is growing at 1 to 2% per year [15] except for solar and wind power which averaged 20% per year in the 2010s. [16, 17].

Per capita energy consumption is very high in North America, while much of Africa has low energy consumption and even more renewable energy [18, 19]. Global energy consumption has decreased significantly due to the COVID-19 pandemic, particularly as demand for new construction in the iron and steel industry has decreased. Rising global demand for products produced by the iron and steel industry is likely to boost consumption in 2019 as well [20].

Of the global annual total greenhouse gas emissions of about 50 billion tons [21], energy (almost all from fossil fuels) accounted for 36 billion tons of carbon dioxide emissions in 2021 [22]. The goals set in the Paris Agreement to limit climate change will almost certainly not be achieved [23]. A number of scenarios are created to achieve the goal.

Table 2. *World total primary energy consumption Scenario last 10 (Ten) Years [3].*

Year	Energy (Mtoe)
2010	12,070.79
2011	12,363.62
2012	12,530.09
2013	12,762.01
2014	12,887.17
2015	13,105.00
2016	13,258.50
2017	13,511.20
2018	13,760.63
2019	13,889.13
2020	13,306.11

Source: BP Statistical Review of World Primary Energy

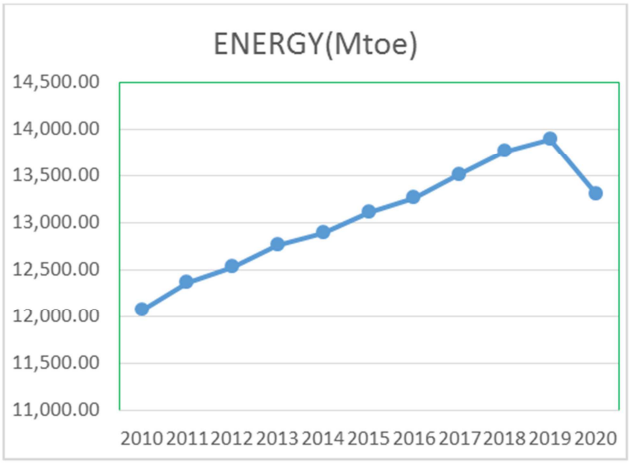


Figure 4. *Year-wise) (2010-20) World total primary energy consumption in MOTE [3].*

Table 3. *World Total Energy 2020 and 2019 Year distribution is given below in tabular form [3].*

Name	Energy (Mtoe)	
	2020	2019
Oil	4160.70	4583.21
Coal	3616.60	3765.17
Natural Gas	3287.00	3356.74
Nuclear Energy	572.75	595.44
Hydro	911.44	900.21
Renewable Energy (Wind, Solar, Biofuels)	757.62	688.36
Total	13306.11	13889.13

Source: BP Statistical Review of World Primary Energy

Table 4. *World Total Energy 2018 and 2017 Year distribution is given below in tabular form [3].*

Name	Energy (Mtoe)	
	2018	2017
Oil	4572.70	4621.90
Coal	3792.63	3731.50
Natural Gas	3311.84	3156.00
Nuclear Energy	577.05	596.40
Hydro	891.85	918.60
Renewable Energy (Wind, Solar, Biofuels)	614.56	486.80
Total	13760.63	13,511.20

Source: BP Statistical Review of World Primary Energy

Table 5. *World Total Energy 2016 and 2015 Year distribution is given below in tabular form [3].*

Name	Energy (Mtoe)	
	2016	2015
Oil	4557.30	4341.00
Coal	3706.00	3784.70
Natural Gas	3073.20	3146.70
Nuclear Energy	591.20	582.70
Hydro	913.30	883.20
Renewable Energy (Wind, Solar, Biofuels)	417.40	366.70
Total	13,258.50	13105.00

Source: BP Statistical Review of World Primary Energy

4. Global Comparative Energy Scenario with Bangladesh

Table 6. *Global Comparative Energy Scenario 2021 given below in tabular form [4].*

Name of Country	Income country	GDP/Capita (USD)	TES/pop (kgoe/cap)	Self sufficiency	Energy Intensity (kgoe/000 USD)
Bangladesh	Lower Middle	1,604.29	260	81.6	170
China	Upper Middle	10,243.83	2,300	80.1	240
Korea	High	30,971.00	5,470	15.8	180
Italy	High	31,752.90	2,490	23.1	80
Japan	High	36,416.34	3,370	11.8	90
Germany	High	43,155.23	3,640	36.9	80
Singapore	High	60,649.12	6,690	2.4	110
Luxemburg	High	105,667.00	6,410	5.6	60

Source: Key World Energy Statistics 2020, IEA un Energy Statistics Pocketbook 2021].

5. Comparison in Energy Mix in Bangladesh with Other Countries

Bangladesh is a small primary energy consuming country. Primary energy potential is not bad, but it should be explored. Currently, the country is facing a huge energy crisis. There is no alternative to increasing the primary energy supply. According to the global and regional context, we lag energy consumption far behind energy supply. Due to carbon emissions and GHG mitigation concerns in our country there should be a comprehensive plan to capitalize on coal (local and imported) as primary fuel to meet the energy demand of SDG 2030 as well as Vision 2041.

(a) *Energy mix of India*

Despite India having significant fossil fuel resources, India remains the world's fourth largest energy consumer after China, the United States and Russia, the country has become increasingly dependent on energy imports. Total energy consumption in 2019 was 31.783 quadrillion Btu (equivalent to 800.92 Mtoe) with a per capita of 23.23 million Btu. Highest percentage came from coal 45%, petroleum product contributed 25%, biomass 20% natural gas 6%, hydroelectric 1%, nuclear 1% and other renewal 1%. Heavily dependent on fossil fuel (70% of total consumption).

Despite having large coal reserves and a healthy increase in natural gas production over the past two decades, India is increasingly dependent on imported fossil fuels. India's primary energy consumption has more than doubled over the past few decades.

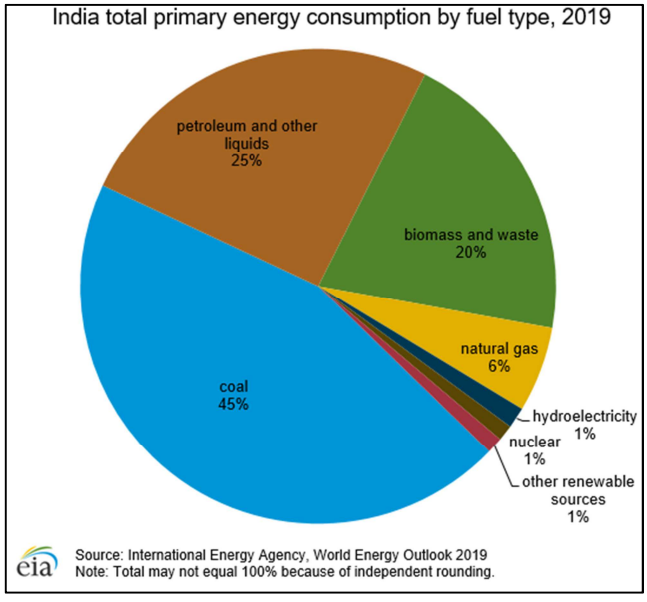


Figure 5. *India Energy Mix [5].*

(b) *Energy mix of China*

China is the world's most populous country with a rapidly growing economy that has made it the world's largest energy consumer and producer. Rapidly increasing energy demand, especially for liquid fuels, has made China highly influential in the global energy market.

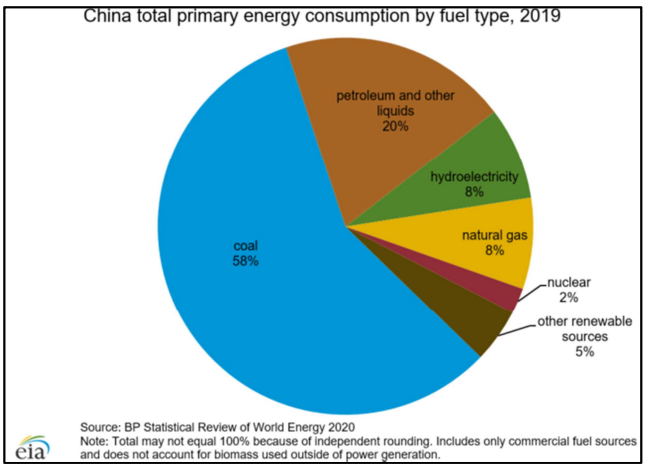


Figure 6. *China Energy Mix [3].*

Coal supplied the majority (58%) of China's total energy consumption in 2019. Oil was the second largest source, accounting for 20% of the country's total energy consumption. Although China has tried to diversify its energy supply, hydropower sources (6%), natural gas (8%), nuclear power (nearly 2%), and other renewables (5%) accounts for a relatively small share of China's energy consumption.

(c) *Energy mix of South Korea*

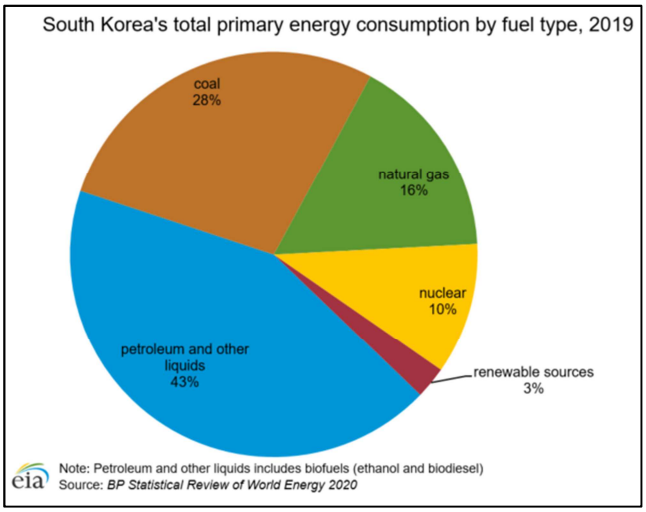


Figure 7. *South Korea Energy Mix [3].*

South Korea has no domestic energy reserves so relies on imports for about 97% of its energy needs as a result of insufficient domestic resources. U.S. The Energy Information Administration (EIA) estimated that South Korea was the ninth largest energy consumer in the world in 2019. Korea is one of the world's top energy importers.

Total energy consumption in 2019 was 12.414 quadrillion Btu. Out of total consumption of energy petroleum product contribute highest at 43%, followed by coal at 28%, natural gas at 16%, nuclear at 10% and other renewables at 3%. Energy consumption is driven by South Korea's highly developed economy, and economic growth is driven by exports, particularly electronics and semiconductor exports. The country has one of the top shipbuilding industries in the world.

(d) *Energy mix of Malaysia*

Malaysia is the world's second largest exporter of liquefied natural gas and the second largest oil and natural gas producer in Southeast Asia. Strategically located by sea within important routes for energy trade. As Malaysia targets economic development and increased manufacturing, the country is focusing on cost-effective energy security and diversifying its energy supply portfolio. Petroleum and other liquids and natural gas are the main primary energy sources consumed in Malaysia, with an estimated share of 37% and 36% respectively in 2019.

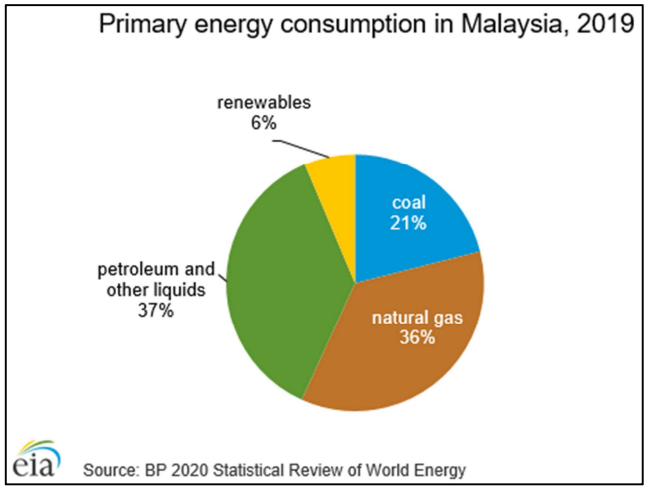


Figure 8. *Malaysia Energy Mix [3].*

About 21% of the country's energy consumption is met by coal. Renewable energy contributes 6% to total energy consumption. The government is emphasizing fuel diversification by importing coal and encouraging investment in renewable energy to reduce overdependence on oil and natural gas to sustain Malaysia's economic growth.

(e) *Energy mix of Russia*

Russia is the world's second-largest producer of dry natural gas and third-largest producer of liquid fuels. Despite having significant reserves of coal, it produces only modest amounts of coal. Russia's economy is highly dependent on its hydrocarbons, and oil and gas revenues account for more than 50% of federal budget revenues. Russia is a major producer and exporter of oil and natural gas, and its economy depends largely on energy exports. Russia's economic growth is driven by energy exports due to high oil and gas production and high prices for those products.

Of the total primary energy consumption, natural gas contains 52%, petroleum 23%, coal 12%, hydro and other renewables contain 7% and nuclear energy 7%. Russia consumed 33.245 quadrillion Btu of total energy with per capita consumption 227.9 million Btu per person (Equivalent to 5,747.638 Kgoe in 2019). Energy consumption per GDP of Russia is 8.8 thousand Btu per USD at purchasing power parities.

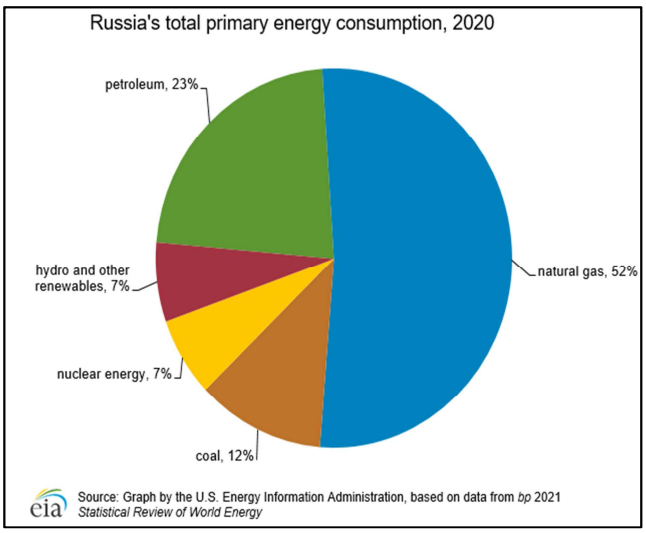


Figure 9. *Russia Energy Mix [6].*

(f) Energy mix of Australia

Australia is a country rich in hydrocarbons and uranium. It is one of the world's largest exporters of coal and one of the world's largest exporters of liquefied natural gas (LNG). Australia has experienced limited energy demand growth because of lower levels of energy intensity compared to a few decades ago. Energy efficiency measures in many end-use sectors, technological advances, and a shift from heavy industries to a more service-sector oriented economy have resulted in a decrease in Australia's energy intensity. Australia is heavily dependent on fossil fuels for its primary energy consumption. In 2019, petroleum and other liquids accounted for an estimated 38% of the country's total energy used. The share of oil consumption has risen in the past few years as it supports the country's commodity production growth, mining, and petrochemical industry as well as the transportation sector.

Coal and natural gas account for 32% and 24% of the energy demand portfolio, respectively. Renewable sources including hydropower, wind, solar and biomass account for more than 6% of total consumption.

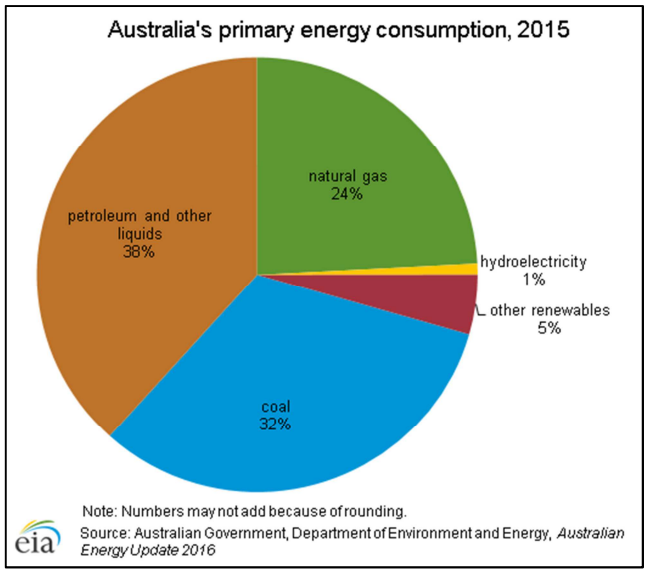


Figure 10. *Australia Energy Mix [7].*

(g) *Energy mix of USA*

The United States is the second largest energy consumer in the world. Most of this energy is derived from fossil fuels. In 2019, data shows that 37% of the country's energy comes from petroleum, 11% from coal, and 32% from natural gas. Nuclear power supplied 8% and renewable energy supplied 11%, which was mainly from hydroelectric dams and biomass but also included other renewable sources such as wind power, geothermal and solar power. In the Renewable Energy (11%) share, biomass accounts for 43%, wind 24%, hydroelectric power contains 22%, solar 9%, geothermal 2% share respectively.

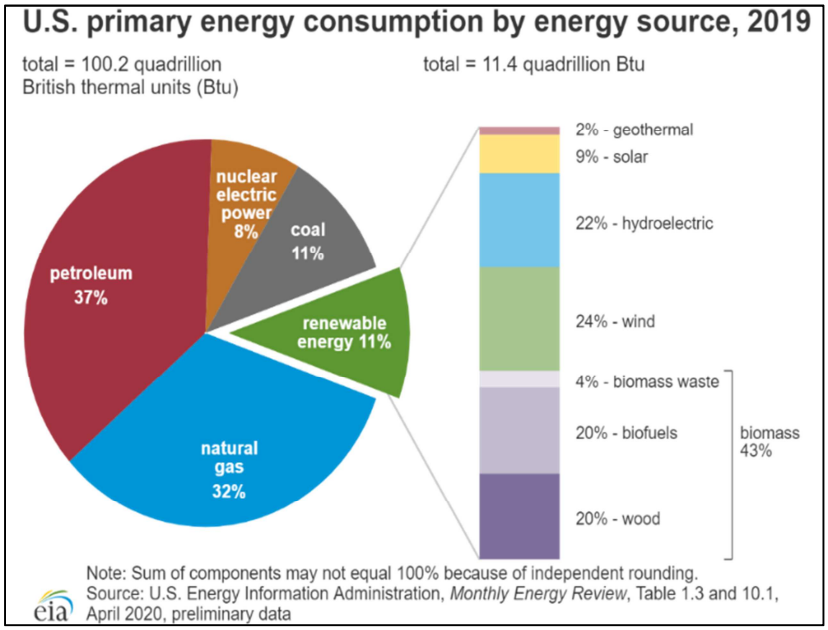


Figure 11. *USA Energy Mix [8].*

6. World Energy Trade, Comparative Energy Mix & Supply and Projection Scenario

6.1. World Energy Conversion and Trade

Primary and Converted energy is traded between countries. The seven countries with large differences in exports in 2021 and the seven countries with large differences in imports in 2021, expressed in Mtoe in Table 7. A negative value indicates that the economy requires a lot of energy imports [24]. The energy produced, for example, crude oil, is processed to make it suitable for Consumption by end users. The supply chain between production and final consumption involves many transformation activities and a lot of trade and transport between countries, resulting in a one quarter of the loss before energy is consumed. Russian gas exports were greatly reduced a lot in 2022 [25] as pipeline plus LNG export capacity to Asia is far less than the gas no longer sent to Europe [26].

Table 7. *World Energy Exports and imports of different countries (Mote) [24].*

Name of Country	Position	Exports minus import's in 2021 Mote
Russia	Upper Middle	682
Saudi Arabia	High Income	388
Australia	High Income	296
Canada	High Income	245
Indonesia	Lower Middle	226
Norway	High Income	185
Italy	High Income	(-) 114
Turkey	Upper Middle	(-) 118
Germany	High Income	(-) 187
South Korea	High Income	(-) 239
India	Lower Middle	(-) 323
Japan	High Income	(-) 357
China	Upper Middle	(-) 803

6.2. 1980 and 2019 World Energy Mix Comparison

U.S. According to Energy Information Administration data, the world's total primary energy supply in 2019 was 602.391 quad Btu (equivalent to 15,192.30 Mtoe) and the world's total primary energy supply in 1980 was 296 quad Btu (equivalent to 7,465,12 Mtoe). The highest primary energy supplier in 2019 was petroleum oil at 33%, second highest was coal at 27%, followed by natural gas at 24%, nuclear at 5%, renewables and others at 11%. Again in 1980 the highest primary energy supplier was petroleum oil 45%, second highest coal 27%, followed by natural gas 18%, nuclear 3%, renewables and others 7%. A comparison of the fuel share in the world's total primary energy supply is shown in Figures 11 and 12 below for 1980 and 2019 from the Energy Information Administration.

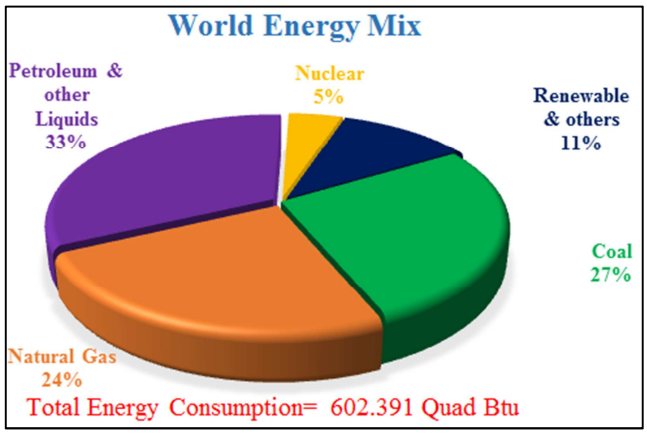


Figure 12. *Energy Mix of World Consumption 2019 [9].*

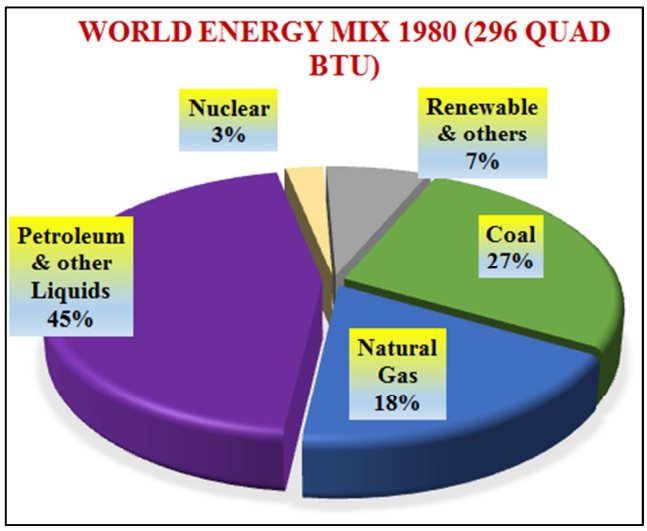


Figure 13. *Energy Mix of World Consumption 1980 [9].*

6.3. Comparison of 1971 and 2019 Total Primary Energy Supply by Fuel

U.S. According to Energy Information Administration data, the world's total primary energy supply by fuel 2019 was 606 EJ. and the world's total primary energy supply by fuel 1971 was 230 EJ [10].

Table 8. *World Energy Supply by Fuel (1971& 20190 [28].*

Fuel Name	1971	2019
Coal	26.1%	26.8%
Oil	44.3%	30.9%
Natural gas	16.2%	23.2%
Nuclear	0.5%	5%
Hydro	1.9%	2.5%
Biofuel	10.8%	9.4%
Other renewables	0.2%	2%

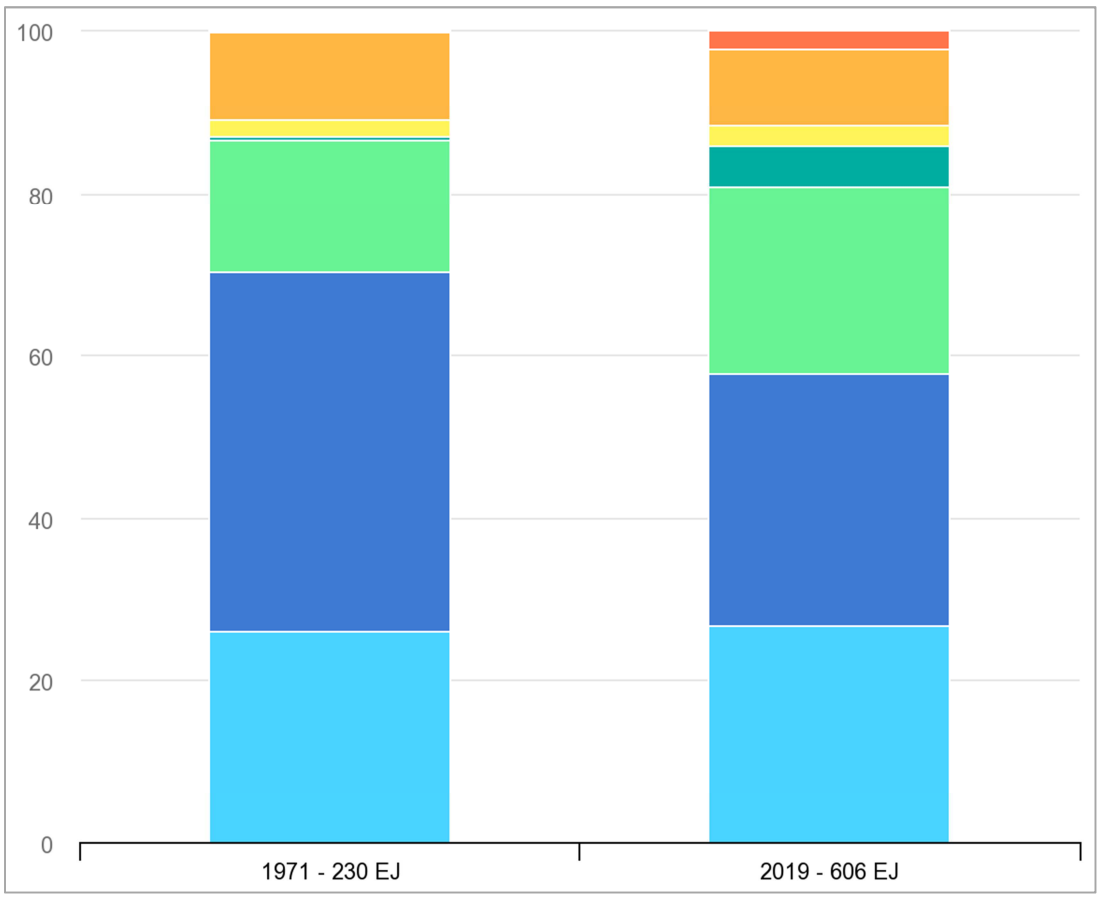


Figure 14. *World total primary energy supply by fuel (1971 & 2019) [10].*

6.4. Projection of World Energy 2035

Total global energy consumption is estimated at 18,301 Mtoe in 2035 and the projected energy mix is: fossil fuels 80%, nuclear 6% and renewables 14% (Figure 15).

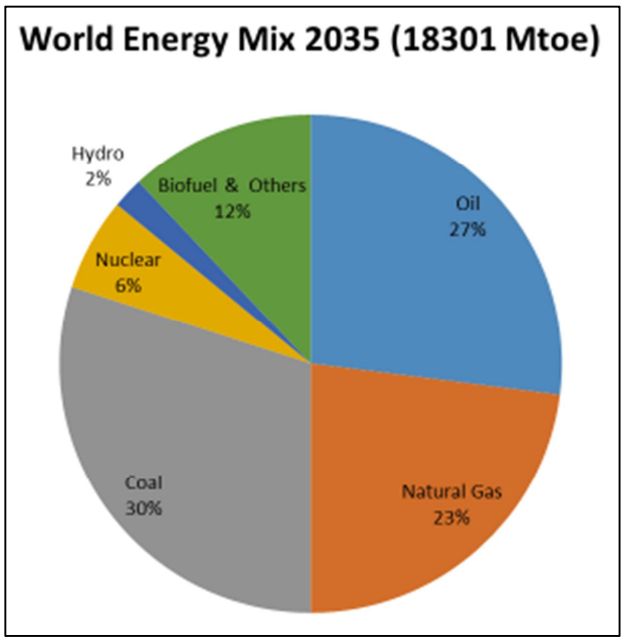


Figure 15. *World Energy Mix 2035 [9].*

It is generally believed that reserves of non-renewable fossil fuels are limited in quantity; Future energy demand of the country should be met by nuclear and renewable energy sources. The above analysis indicates that the major part of the world's energy in 2035 will be met by fossil fuels.

It can be assumed that nuclear and renewable energy will play a more important role in meeting the total energy demand of Bangladesh than fossil fuels in the future.

7. Energy Economic Relation

(a) *Energy and Social Development*

Energy is an essential commodity for most human activities, either directly (as fuel) or indirectly (to provide power, light, mobility). In traditional societies, populations depended on their own physical energy for labor, then on the power of domesticated animals, such as horses and oxen, then water and wind, steam engines, hydrocarbons (fuel motors for land, sea and air vehicles) and finally - electricity. In combination with technology, mankind multiplies energy (e.g. motor fuel for cars, electricity for household appliances), leading to the important role played by pre-industrial and then IT societies. For other essential needs like space heating and cooking, there has been a shift from local biomass (e.g. firewood, agricultural waste) to industrial fuels (e.g. LPG, natural gas) and also electricity. Access to reliable and

affordable modern energy services acts as a barrier to economic and social development.

(b) *Energy-Economy Nexus*

Energy plays an important role in socio-economic development. Energy is consumed to meet demand for subsistence (e.g. cooking, lighting, room heating etc. at household level) and for productive activities (e.g. agriculture, industry, transport, commercial etc.). In Least Developed Countries (LDCs) a major proportion of total energy is consumed to meet subsistence needs. Demands are mainly met by traditional energy sources including biomass fuels and a small portion is consumed in the productive sector using commercial energy resources (such as coal, oil, natural gas and hydropower).

As a country moves up the economic ladder, energy also moves from an inferior energy to a superior energy. As per capita commercial energy consumption increases, the proportion of energy used for subsistence needs decreases and productive demand increases. In industrialized countries, a major part of energy is consumed to meet productive needs and a small part to meet subsistence needs. A country's economic growth mostly depends on energy. A country's economy is integrated with energy consumption, economic growth, capital, manpower. It shows that there is a positive relationship between commercial energy consumption per capita and GNI per capita; This means that increasing per capita GNI requires an increase in per capita consumption of commercial energy. This correlation differs between developing, underdeveloped and developed countries.

(c) *Energy Economic relation in Bangladesh*

In Bangladesh, some civil society spokesmen want to raise the country's economic status to an upper-middle-income country by 2031 and a high-income economy by 2041, not to mention the growing energy demand. According to World Bank, per capita GNI of Bangladesh, low-income, lower middle-income, upper middle-income and high income economies were US$ 2,030, GNI >US$ 1045, GNI 1,046 – 4,095 US $, GNI 4,126-12,745 US $ and GNI >12,746 US $ respectively. A plot of Energy Consumption per capita (Million Btu/Person) vs. Energy Consumption per GDP (Thousand Btu/USD at PPP) of some selected Countries in 2019 is shown in Figure 15. Energy Consumption per capita (Million Btu/Person) of Bangladesh is 9.92 MBtu/person.

It is very appreciable that Bangladesh has already attained lower middle-income level and aspires to attain upper middle income economy (US$ 4,126 – 12,745) by 2031. Policy planners and decision makers need to recognize the growing need for energy to achieve higher per capita GNI levels. Increasing the projected consumption of energy on a sustainable basis will be a challenging task.

(d) *Energy Economic Relation in others Countries*

Developed and industrialized societies use more energy per capita in economic production than poor societies, especially those in pre-industrial states. Energy consumption per unit of output is expected to decline as industrialization advances, reflecting changes in the structure of economic activity as well as the adoption of increasingly more efficient technologies for energy production and use. Energy intensity in today's developing countries probably reached a much earlier and lower level along the development path than it did during the industrialization of today's developed world. But even with trends toward greater energy efficiency and other shrinking factors, total energy use and per capita energy use continue to rise in advanced industrialized countries. Even if energy is linked to development, several other steps are involved, particularly the evolution of education and labor markets, industrialization, job creation, financial institutions to support capital investment, modernization of agriculture, and provision of infrastructure for water, sanitation, and communication. It is hard to imagine overall economic development succeeding without energy development being an integral part of the evolution. So the Table 7 energy consumption of some countries on income level 2019 is as follows:

Table 9. *Energy consumption of some countries on income level 2019 [11].*

(i) Lower Middle Income Country (GNI per capita USD1,046- USD 4095).

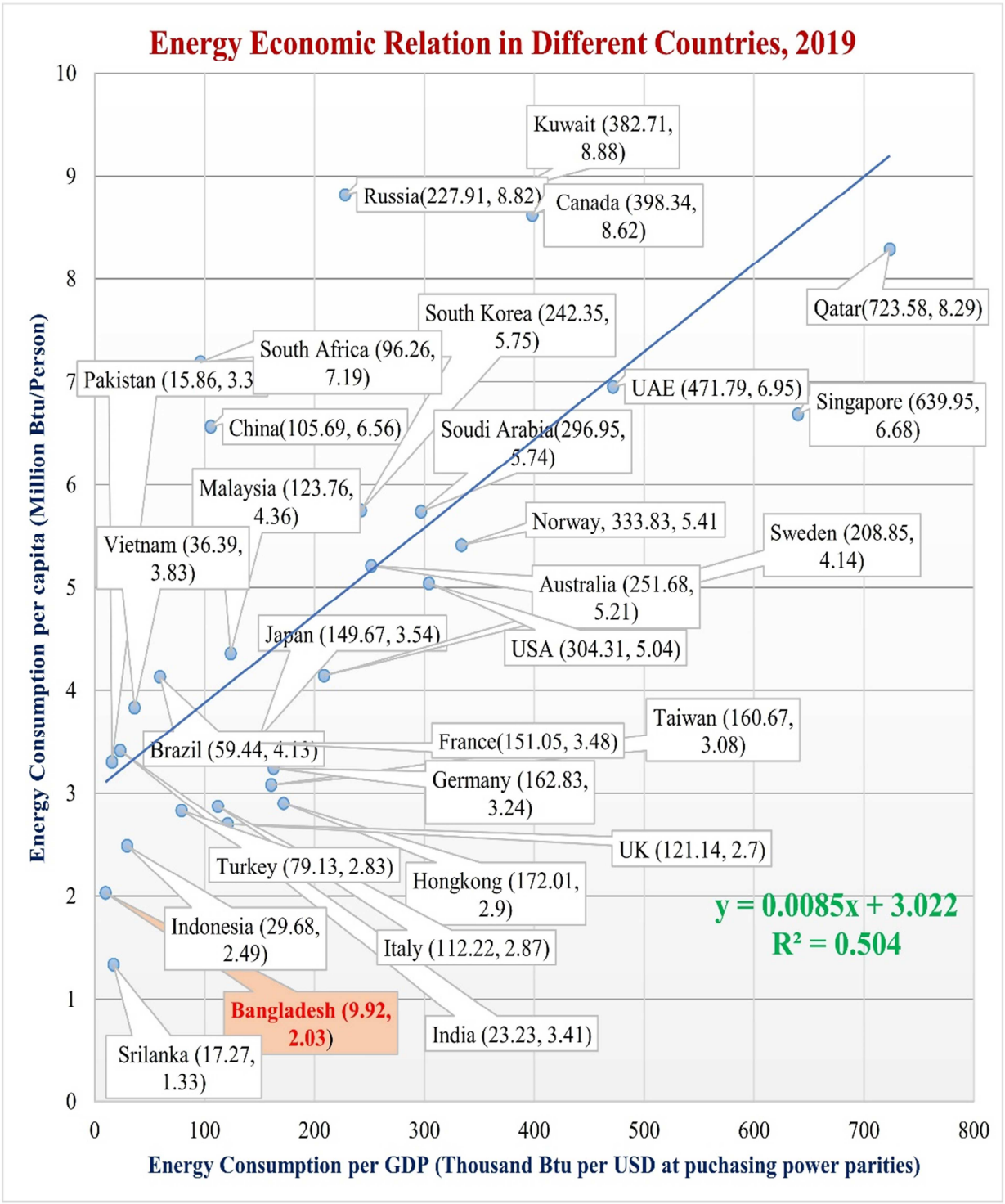
Name of Country	GDP/Capita (USD)	Energy Consumption Per GDP (Thousand Btu/USD at PPP	Energy Consumption Per Capita (MBtu/Person)	Total Energy Supply/Capita (GJ/Capita)
Bangladesh	1,604.29	9.92	2.03	11.20
Pakistan	1,487.07	15.86	3.30	21.50
India	1,988.29	23.23	3.41	28.70
Vietnam	2,603.11	36.39	3.83	39.60
Srilanka	4,229.36	17.27	1.33	23.20

(ii) Upper Middle Income Country (GNI per capita USD 4,126- USD 12,745).

Name of Country	GDP/Capita (USD)	Energy Consumption Per GDP (Thousand Btu/USD at PPP)	Energy Consumption Per Capita (MBtu/Person)	Total Energy Supply/Capita (GJ/Capita)
South Africa	5,569.97	96.26	7.19	100.20
China	10,243.83	105.69	6.56	101.50
Russia	10,010.39	227.91	8.82	224.10
Malaysia	11,365.63	123.76	4.36	120.40
Turkey	12,076.27	79.13	2.83	74.50

(iii) High Income Country (GNI per capita USD 12,745 and above).

Name of Country	GDP/Capita (USD)	Energy Consumption Per GDP (Thousand Btu/USD at PPP	Energy Consumption Per Capita (MBtu/Person)	Total Energy Supply/Capita (GJ/Capita)
Japan	36,416.34	149.67	3.54	137.80
France	40,258.46	151.05	3.48	150.50
Australia	52,700.79	251.68	5.21	212.50
Singapore	60,649.12	639.95	6.68	252.70
USA	60,805.18	304.31	5.04	282.00



Energy Consumption Per GDP (Thousand Btu/USD at PPP = X and Energy Consumption Per Capita (MBtu/Person) = Y

Figure 16. *Energy – Economy Relation in Different Developed & Developing Countries' 2019 [11].*

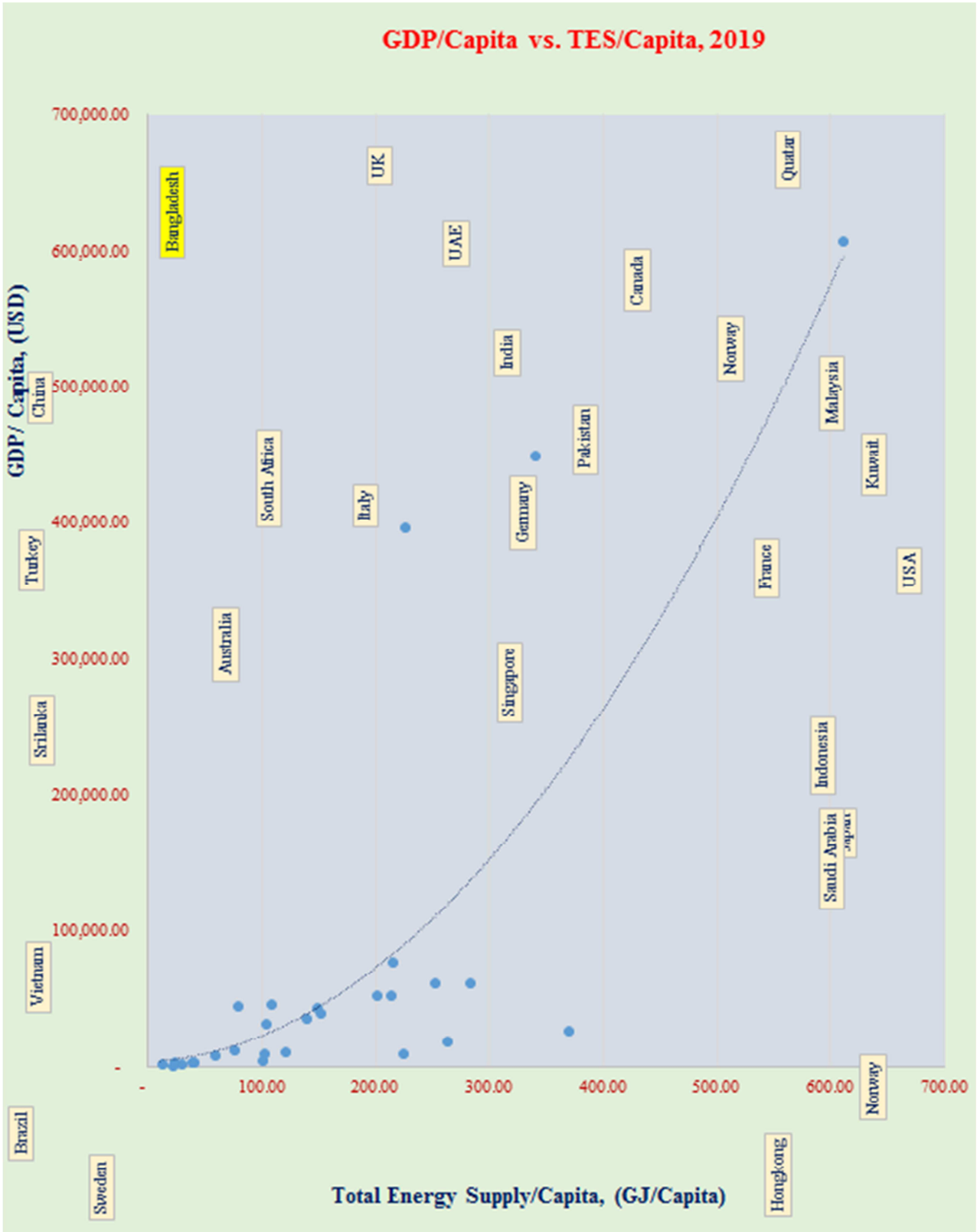


Figure 17. *GDP/Capita vs TES/Capita in Different Developed & Developing Countries'2019 [11].*

8. Result and Discussion

Energy is on top of Bangladesh's low level of consumption and is already facing a serious energy crisis that has resulted in sluggish growth in energy supply while energy demand has skyrocketed with higher economic growth. Clearly, a well-designed sustainable long-term strategy to address the energy crisis and increase energy supply is urgently needed to support Bangladesh's development. Alternatives to energy

from domestic sources need to be complemented with potential alternatives to energy trade. Specifically, the strategy will address what governments can do about gas and electricity and look at energy diversification options for generation. The strategy will also explore alternative solutions such as increased electricity imports from neighboring countries and LNG trade. Furthermore, exploration of domestically available resources, such as coal and oil and gas from offshore drilling, will be intensified and nuclear and renewable energy will be looked at. Supply side options will be balanced with demand management policies that conserve energy and discourage inefficient use of energy.

To determine the energy-economy relationship of developed, underdeveloped and developing countries are shown in Figure 16. It is clear from the figure that although the relationship is not linear, a country's GNI per capita generally depends on energy consumption per capita.

8.1. Energy Requirement in Bangladesh 2041

To make Bangladesh a developing income country, the per capita income should go above 12,745 US dollars. If Bangladesh is to achieve the vision of becoming a developing income country by 2041 with a per capita income of 14,500 US dollars there will be a drastic increase in energy consumption resulting in an increase in energy supply. From the energy economic relationship of some developing countries in Figure 15, it can be seen that there is a linear relationship between them and the relationship can be represented by the equation $y = 0.0085x + 3.022$ with R square of 0.504. From the diagram for energy consumption per GDP 145 thousand Btu/USD at purchasing power parities of a country energy consumption per capita should be around 4.25 Million Btu per person.

8.2. Electricity & GDP Growth Rate Through Collected Peak Demand in High Case and Macroeconomic Frame Work for the Perspective Plan of Bangladesh 2041

Table 10. *Electricity & GDP Growth Rate through Collected Peak Demand in high case and Macroeconomic Frame work for the Perspective Plan of Bangladesh 2041 (without EE& measures) [12].*

Year	Electricity and GDP Growth rate (GDP Growth rate through collected Peak Demand in High Case)		Macroeconomic Frame work for the perspective plan of Bangladesh 2041	
			Macro Projection perspective plan scenario	Macro Projection BAU scenario
	Electricity G.R%	GDP G.R%	GDP G.R%	GDP G.R%
2030	7.0	6.2	8.9	7.2
2031	7.0	6.1	9.0	7.1
2035	6.0	5.4	9.4	6.7
2036	6.0	5.2	9.5	6.6
2040	6.0	4.9	9.8	5.8
2041	5.0	4.9	9.9	5.5

8.3. Per Capita Energy Generation and Consumption Projection up to 2041 in Bangladesh

Table 11. *Per Capita Generation and Consumption Projection up to 2041 in Bangladesh [12].*

	Year	2030	2035	2041
	Population (Million)	186	193	198
	Average Growth rate	0.8	0.6	0.5
High case	Energy generation, Demand	237,113	340,961	473,359
	Per capita Generation	1275	1767	2391
	Energy Consumption, Demand	212,928	307,103	426,638
	Per capita Consumption	1145	1591	2155
	Year	2030	2035	2040
	Energy generation, Demand	224,507	322,841	446,025
Base Case	Per capita Generation	1207	1673	2253
	Energy Consumption, Demand	201,608	290,783	402,002
	Per capita Consumption	1084	1507	2030
	Year	2030	2035	2040
	Energy generation, Demand	209,570	301,351	416,338
Low Case	Per capita Generation	1127	1561	2103
	Energy Consumption, Demand	188,194	271,427	375,245
	Per capita Consumption	1012	1406	1895

8.4. A New Energy Economy Is Emerging

There are unmistakable signs of change. In 2020, even as economies sank under the weight of Covid-19 lockdowns, additions of renewable sources of energy such as wind and solar PV increased at their fastest rate in two decades, and electric vehicle sales set new records. A new energy economy is coming into view, ushered forward by policy action, technology innovation and the increasing urgency of the need to tackle climate change. There is no guarantee that the emergence of this new energy economy will be smooth, and it is not coming forward quickly enough to avoid severe impacts from a changing climate. But it is already clear that

tomorrow's energy economy promises to be quite different from the one we have today.

8.5. Net Zero Emissions by 2050 Projection Scenario of the World

Announced net zero pledges and updated NDCs, reflected in full in the Announced Pledges Scenario, represent an important boost to the world's efforts on climate but, as they stand, they close less than 20% of the gap in 2030 between the STEPS and the NZE. An additional 12 Gt CO_2 emissions need to be abated in 2030 in order to get the world on track for the NZE, and this needs to be accompanied by reductions of almost 90 million tones (Mt) in methane emissions from fossil fuel operations (equivalent to another 2.7 Gt of CO_2 emissions) [13]. That is the task before the world's decision makers as they assess how to keep a 1.5°C stabilization in global average temperatures within reach.

Table 12. *Selected indicators in the Net Zero Emissions by 2050 Scenario [13].*

	2030	**2040**	**2050**
Global indicators			
CO_2 emissions per capita in AE (t CO_2 per capita)	4	1	0
CO_2 emissions per capita in EMDE (t CO_2 per capita)	2	1	0
CO_2 emissions intensity (t CO_2 per USD 1000, PPP)	114	25	0
Energy intensity (MJ per USD, PPP)	3.0	2.2	1.7
Share of electricity in TFC	26%	39%	49%
Share of fossil fuels in TES	62%	35%	22%
Share of population with access to electricity in EMDE	100%	100%	100%
Investment in clean energy (billion USD)	4 344	4 348	4 210
Total CO_2 captured (Mt CO_2)	1 665	5 619	7 602
Supply			
Emissions intensity of oil and gas (kg CO_2-eq per boe)	40	35	31
Methane emissions from fossil fuel operations (Mt CH_4)	28	14	10
Low-carbon share in total liquids	10%	21%	39%
Low-carbon share in total gases	14%	33%	62%
Low-carbon share in total solids*	39%	55%	72%
Electricity generation			
CO_2 emissions intensity (g CO_2 per kWh)	138	-1	-5
Share of unabated coal	8%	0%	0%
Share of renewables	61%	84%	88%
Share of wind and solar PV	40%	63%	68%
Buildings			
CO_2 emissions intensity (g CO_2 per MJ)	18	8	1
Existing buildings retrofitted to be zero-carbon-ready level	20%	50%	85%
Share of new buildings that are zero-carbon-ready	100%	100%	100%
Appliance unit energy consumption (index 2020=100)	75	64	60
Industry			
CO_2 emissions intensity (g CO_2 per MJ)	41	21	3
Energy intensity (MJ per USD PPP)	3.0	2.3	1.7
Share of electricity in TFC	28%	37%	46%
Transport			
CO_2 emissions intensity of passenger cars (g CO_2 per km)	106	34	4
CO_2 emissions intensity of heavy trucks (g CO_2 per km)	589	273	54
Share of low-carbon fuel use in aviation and shipping	17%	51%	81%
Share of PHEV, BEV and FCEV in total passenger car sales	64%	100%	100%
Share of PHEV, BEV and FCEV in total heavy truck sales	30%	84%	99%

*Traditional use of biomass is not considered low-carbon.

Notes: AE= advanced economies; EMDE= emerging market and developing economies; PPP= purchasing power parity; TFC= total final consumption; TES= total energy supply; Mt CO_2= million tonnes of CO_2; kg CO_2-eq per boe = kilogrammes of CO_2 equivalent per barrel of oil equivalent; Mt CH_4= million tonnes of methane; g CO_2 per kWh= grammes of CO_2 per kilowatt-hour; g CO_2 per MJ= grammes of CO_2 per megajoule; g CO_2 per km = grammes of CO_2 per kilometre; PHEV= plug in hybrid electric vehicle; BEV= battery electric vehicle; FCEV= fuel cell electric vehicle.

The four key priorities for action to close this gap over the next decade, and to prepare the ground for further rapid emissions reduction beyond 2030, are to:

1) Deliver a surge in clean electrification.
2) Realize the full potential of energy efficiency.
3) Prevent methane leaks from fossil fuel operations.
4) Boost clean energy innovation.

8.6. Liquid Fuels Remain the Largest Energy Source But Renewable Energy Use Grows to Nearly the Same Level

Renewable energy use is driven by favorable technology costs and government policy, but it does not replace

petroleum and other liquid fuels absent future technology breakthroughs or significant policy changes.

After coal consumption declines by 2030, consumption of all major fuels will increase from 2030 to 2050. Renewable energy use will more than double between 2020 and 2050, and renewable energy consumption will nearly equal liquid fuel consumption by 2050. The rise of renewable energy which accounts for 27% of global energy consumption in 2050 [27] results from declining technology costs and government policy changes, thereby contributing to the electric power sector using renewable energy sources to meet growing electricity demand.

Although natural gas consumption increases by 31% through the projection period, the share of renewable energy consumption, which increases from 15% in 2020 to 27% in 2050 [27], limits the share of global energy use fueled by natural gas which slight decrease from 24% to 22% over the same period [27]. The low relative price of natural gas in the near term as well as the need for intermittent renewable supplies are important drivers of natural gas use.

Electricity use increases in all end-use sectors and grows faster than total energy consumption.

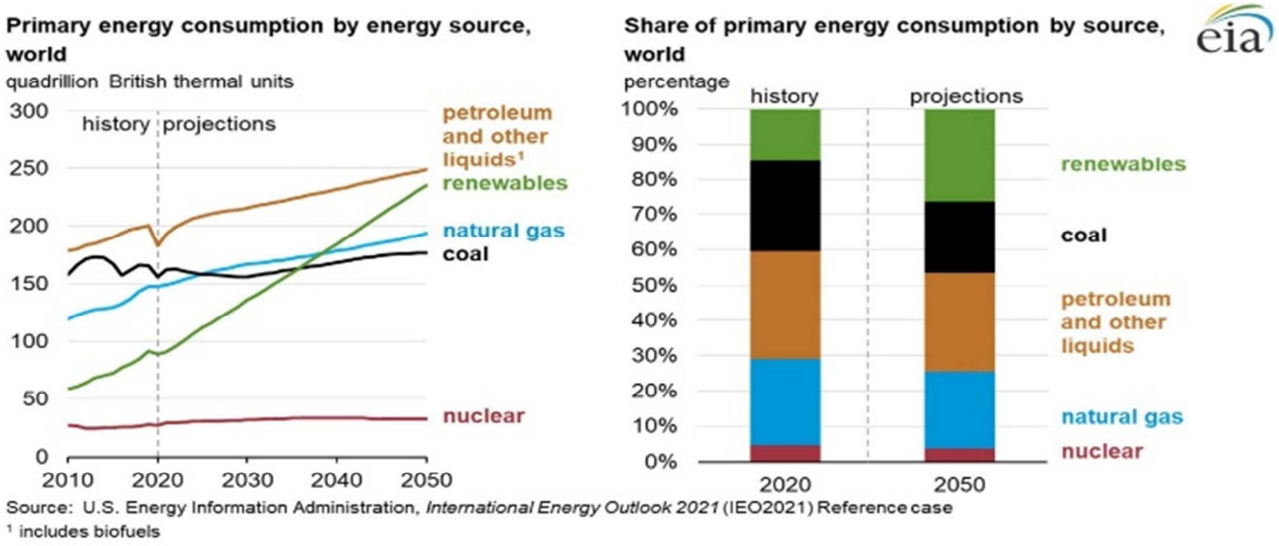


Figure 18. *Primary energy consumption and share of Primary energy consumption by energy sources and sources of the world [27].*

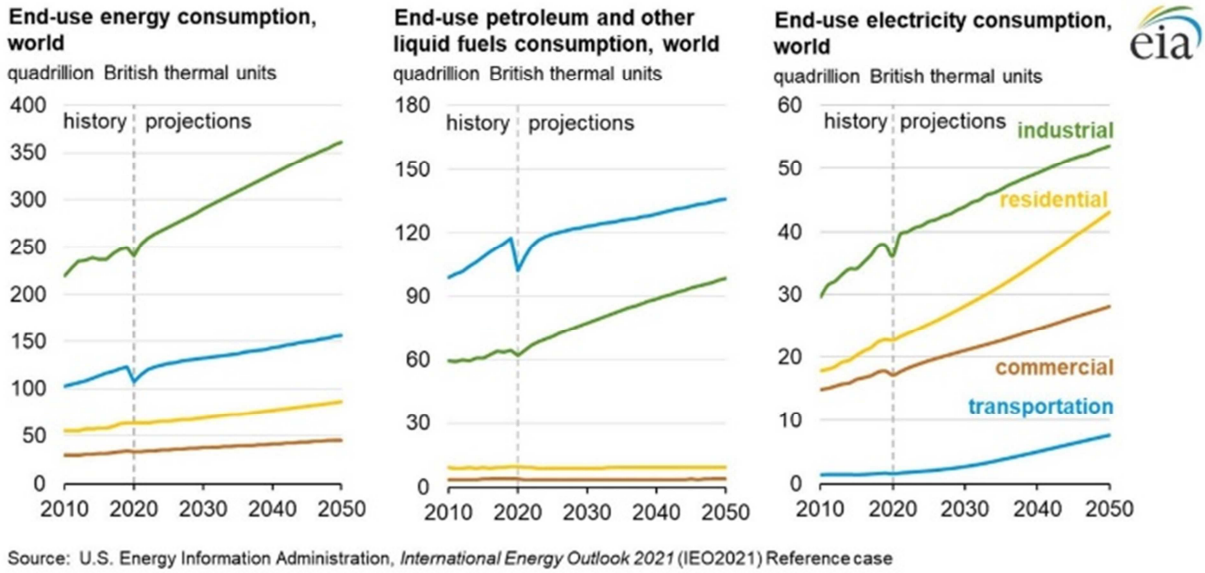


Figure 19. *Electricity use increases in all end-use sectors and grows faster than total energy consumption [27].*

Despite efficiency gains, global end-use sectors will increase energy consumption by 2050 We anticipate growth in electricity demand across all sectors, outpacing global population growth.

Petroleum liquids such as motor gasoline, distillates, and jet fuel continue to grow and may meet transportation energy needs over the next 30 years, as the world's population grows and passenger and freight travel expands. Electricity use, however, starting from a relatively small base, grew about six times faster than petroleum use over the same period [27].

9. Challenges for Implementation of Bangladesh Vision 2041 and Future Recommendation

9.1. Challenges for Implementation of Vision 2041

1) Affordable, Reliable and Modern Energy for all.
2) Energy Efficiency & Conservation.
3) Clean Fuel and Technology.
4) Suitable Energy mix.
5) Increase share of Renewable Energy.
6) On-shore and Off-shore exploration and production of gas.
7) Developing domestic Coal production and supply.
8) Huge financing of Energy related projects and also ensuring availability of foreign currency.
9) Narrowing demand and supply gap.
10) Efficient use of gas.
11) Market price adjustment.
12) Imported Energy (LPG & LNG).
13) Energy pricing and subsidies.
14) Long term sustainability of import coal.
15) Construction of deep sea port for coal handing.
16) Ensuring safe nuclear technology.
17) Transportation of fuel and equipment, issues which need to be addressed include developing roads and railway infrastructure and dredging of river routes.
18) Building the adequate and skilled human resources.

9.2. Future Recommendation

(i) Energy conservation act should be enacted and that should be strictly enforced;
(ii) (ii) Optimal utilization of natural gas should be ensured in all sectors;
(iii) Electricity prices should be rationalized and the target group can get the benefit of subsidy not common to all;
(iv) Natural gas should be limited and phased out in the captive power sector;
(v) The latest generation of all energy intensive industries require energy adaptation of efficient technologies;
(vi) Inefficient, old installations should be replaced and rehabilitated with modern latest generation energy efficient plants and machinery should be phased out.;
(vii) LPG should be used instead of natural gas and domestic use of natural gas should be phased out;
(viii) viii) Energy audits should be conducted in energy intensive industries such as power plant, fertilizers, manufacturing and process industries;
(ix) Action programs should be taken to standardize plant and machinery based on modern latest generation technology in various energy consuming sectors;
(x) Energy efficient green building technologies should be encouraged and incorporated into National Building Code;
(xi) Energy efficient vehicles like hybrid vehicles should be promoted;
(xii) Energy taxes should be introducing for conservation of energy.
(xiii) Emphasis should be placed on exploration to discover undiscovered gas resources.

10. Conclusion

Energy security is an important element for the implementation of Bangladesh Government's Vision 2041. Building an integrated and developed energy sector with a diverse fuel mix to ensure energy security. Which should be a key driver of a sustainable local and national economy while achieving global competitiveness in all sectors by 2041. So the plan must be consistently quick and timely to ensure that decisions are made very quickly. Greater role of private sector in energy should be encouraged. Ensure transparent governance of energy-related government institutions; enhance human capital development; To support the development of the energy sector through physical and procedural frameworks; To contribute to the protection and enhancement of the natural environment. Renewable energy should also be promoted, such as wind energy, solar energy, biogas and biomass, and energy and energy access for all should be ensured.

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