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Sustainable Energy Sector for Fast Growing Economy like Bangladesh: How Relevant are the Past Asian Precedents?

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Abstract – This article presents a comparative analysis of the historical fast growth phase of the selected Asian countries-South Korea, Malaysia, Singapore and China and Bangladesh focusing on the energy sector. The countries fueled their fast growth phase in the past century by heavy dependence on high carbon fossil fuel. In the changed framing of development through climate change induced sustainability criteria, latecomers in the development process like Bangladesh of this century are better positioned to critically think in building a sustainable energy sector as majority of energy systems will be built now. Unlike Asian predecessors who might need to prematurely shut down carbon intensive energy facilities or decarbonize the existing ones at a high cost, Bangladesh has multiple opportunities to build new low carbon energy infrastructure avoiding high lock-in effect. For Bangladesh current power generation capacity is envisaged to grow by almost a factor of three over next two decades. Setting the goal of steering the energy sector on sustainable pathway through source diversification, cheap renewable and cleaner fuel penetration, energy efficiency, reliable access can not only drive the economic growth faster but positively impact human wellbeing and reduce inequity simultaneously for the fast growing Bangladesh through next two decades.

Keywords – Asia, Sustainable energy sector, Bangladesh, Fast growing economy, Fossil fuel.

1. INTRODUCTION

Bangladesh with ~160 million people has attained lower middle-income country status in 2015 with ~6.5% yearly GDP growth rate over the last decade and attained over 8% growth in the 2019 [1]. This fast rate of economic development will need to be at least maintained given the committed national goal of catching up with the developed country status by 2041. Moreover, post COVID19 recovery phase necessitates this growth rate for lifting the economy from extreme job and production losses. To revive, stabilize and sustain the economic growth energy sector will play crucial role as a major driver of social, economic and environmental development. One class of traditional development economics literature [2] argues in favor of looking for precedence in catching up by the late comers in development process through replication of development process of predecessors. While leapfrog is also shown as a possible way forward option where there is no need to follow the same historical path of development stages. In this paper, we present lessons learnt from an analysis of the historical fast growth phase of the selected Asian countries -South Korea, Malaysia, and Singapore

focusing on the energy sector. Evidence clearly show these countries during last five decades fueled their growth by heavy dependence on fossil fuel. Development context today in the world has moved to the goal of sustainable development especially after adopting the agenda titled "Transforming our world: the 2030 Agenda for Sustainable Development" in 2015 UN General Assembly. Around the same time Paris agreement has been signed by the countries including Bangladesh.

In this backdrop the objectives of the article are: to define first what do we mean by fast growing economy in Section 2 below and in Section 3 to compare energy supply sector of Bangladesh with Asian predecessors. Section 4 develops the narrative to show how the fast growth phase can adopt overarching sustainability goal and take advantage of changing energy market condition to create a new window of opportunity for Bangladesh towards targeting a sustainable energy sector development in next two decades. Section 5 presents the discussions and conclusions.

2. FAST GROWING ECONOMY: DEFINITION AND CONCEPT AS ADOPTED IN THIS STUDY

Economic growth is the increase of goods and services of an economy. Typically, the production of goods and services are measured by the metric Gross Domestic Product (GDP) and economic growth rate is shown by GDP growth rate [3]. Status of economic progress has been varied at any point of time across the nations and regions. While some countries experience high GDP growth (China 8.26% annual average between 2009-2017), some face moderate growth (Costa Rica 3.47% annual average between 2009-2019), some are stagnant (Finland 0.11% annual average between 2009-2019) and

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some face even negative (Greece -2.81% annual average between 2009-2017) [4]. Thus, the countries can be classified based on their historical growth rate and these can be fast growing, moderately growing, stagnant and negatively growing country based on their growth rate.

Countries are commonly classified as developing and developed from 1960 for policy discussion and resource transfer from richer to poor [5]. Although there is no formal way for defining countries as developing,

159 countries are categorized as developing by United Nations. American and European countries with Australia, Japan and New Zealand are categorized as developed, and the remaining countries are considered as developing [6]. International organizations classify the countries based on their different aspects of development as shown in Table 1. First group of LDCs was listed by the UN in its resolution 2768 (XXVI) of 18 November 1971.

Table 1. Classification of the countries by IMF, UNDP and World Bank.

Typology	IMF	UNDP	World Bank
Developed countries	Advanced countries	Developed countries	High income countries
Developing countries	Emerging and developing countries	Developing countries	Low and middle income countries
Developed countries share in 1990	13 %	25 %	16 %
Developed countries share in 2010	17 %	25 %	26 %

Source: [7]

Table 2. World Bank country classification.

Threshold	Per capita GNI (current USD), using Atlas method of WB
Low-Income	less than 995
Lower Middle Income	Between 996 and 3895
Upper Middle Income	Between 3896 and 12055
High Income	More than 12055

Source: [10]

Classification criteria of IMF are i) level of income per capita ii) diversification of export iii) integration to global financial system. However, the criteria are not limited to these factors alone. Other factors are also considered for classifying the countries [8]. UNDP classify the countries depending on the value of Human Development Index (HDI) that considers various dimension of development. HDI is calculated from the three main indicators: achievement in life expectancy, income and education of a county. Besides, it also incorporates some other features of development such as political freedom, personal security and adjustment of inequality [9]. World Bank classification considers per capita Gross National Income (GNI). The most recent World Bank classification criteria are shown in Table 2 and the status of selected Asian countries are shown in Table 3.

3. ASIAN PREDECESSORS AND BANGLADESH

3.1 Comparative Analysis of Economic Growth Patterns of Selected Asian Countries

Several Asian countries experienced remarkable economic progress in the past century but over varying time periods. South Korea and Singapore achieved more than 8% annual GDP growth rate during the period 1966

to 1990. Although, in late 1990s, financial crisis hit these countries, this high GDP growth rate continued for more than 25 years. It has become an interesting example to countries, who started the development processes late, to follow the similar economic growth path in their own countries [12], [13]. Young, 1995, found that instead of total factor of productivity (TFP) improvement in these East Asian countries remarkable economic growth was driven by high growth of capital and labor input.

Table 3. Asian countries and status.

Country	Status
Bangladesh ²	Lower middle income from 2014
China	Become lower middle income in 2001 and upper middle income since 2010
Malaysia	Upper middle income since 1992
Singapore	High Income before 1987
South Korea	High Income since 2001

Source: [10]

² 2018 meet UN Graduation from LDC for the first time [11]

There were population growth and rise in labor participation rate in all these countries. Amplified flow rate of national savings led to rapid growth in capital stock. Gross domestic saving (% of GDP) increased from 13% in 1966 to 46% in 1990 for Singapore and 11% in 1966 to 39% in 1990 for South Korea. But maintaining long term high growth is difficult by only increasing inputs as that can lead to the decline of marginal productivity of capital. Thus, the resumed rapid growth indicates that later these countries found ways to stimulate growth in TFP [4], [14]. Singapore followed import substitution driven development strategy before 1965. But, it changed to export based economy after its independence in the year 1965. Labor intensive industry was transformed to high capital based heavy industry mostly between 1970 and 1980. Singapore also emphasized the expansion of tourism and other services by prolonging working hour and creating brighter city during the night [15].

South Korea's GDP growth had been on an annual average rate of 9.6% from 1963 to 1996 [4]. The economy was dependent on agriculture in 1960s and faced all types of obstacles like any other developing country [16]. In 1961, military led government focused on economic development using low wage educated labor force for producing goods for export. Development shifted from labor based industry to high capital industry with the rise of wage. Manufacturing sector that focused on textile and footwear initially, shifted to steel and heavy industries in 1970s and to automobiles and electronics in 1980. The rapid industrialization and economic growth helped South Korea in 1996 to join in OECD group [17].

China achieved remarkable economic progress with 9.8% growth rate of GDP annually between 1978 and 2009 [18]. The driving factors for this huge growth were export, consumption and investment growth. The economy of China is in transition phase and moving from primary industry to secondary and tertiary industry. The focus moved on export based light industry and tertiary industry. The increasing number of secondary industry increased urbanization rate and the income of the people. Thus the number of middle income people also rose significantly [19].

During the period of 1961 to 1997, Malaysia experienced rapid economic growth with a rate of 7.37% annually. Later it experienced two financial crises in 1998 and 2009 [4]. Before 1957, Malaysia was an agriculture dependent low-income country and mainly based on tin and rubber production. State led effort towards diversification of the economy is one of the key drivers of outstanding economic growth. Initially, the country focused on agricultural diversification by replacing the production of rubber to palm oil and others. The second part of diversification was primary to secondary industries. Malaysian economy observed fast structural change during 1955-1970. Agriculture dominated primary industry share dropped in GDP from 46.5% in 1955 to 36.1% in 1966. On the other hand,

secondary and tertiary industry sector rose from 11.2% to 15.4% and 42.3% to 48.6% respectively during the same time span. During 1970, manufacturing and construction sector experienced significant growth and by the year of 1990, the economy became further industrialized. Initial industrial growth was inspired by import replacement policy. Later, the wave went to export based manufacturing industries in 1970. Besides, State aided tax concession policy also helped to intensify these industrial growth [20].

Bangladesh has embarked on a significant economic growth path over the last decades. The structure of Bangladesh economy has moved from agro-based to non-agricultural manufacturing industry oriented economy although there is significant improvement through agricultural modernization. Contribution of the industry sector in GDP increasing with time from 6.06% in 1972 to 27.27% in 2017. On the other hand, agricultural sector contribution in GDP is reduced from 59.60% to 13.41% during the same period. This structural change is dominated by the export of labor intensive ready-made garments industry that provide 81.23% of total national export with an annual increase rate of 8.6% in 2016-17 [4], [21], [22]. Heavy industry such as metallurgy, machinery and equipment, energy, chemicals, building materials *etc.* are also growing.

Move towards heavy/export oriented industries in all countries mentioned above was made possible by significant increase in energy supply to meet the growing demand. But with increasing wage, the structure of the economy shifted from labor intensive industry to capital intensive heavy industry that further geared up energy demand. Bangladesh is now based on labor intensive export oriented industries. Following the path of predecessors would mean extensive energy intensive industrialization to sustain its economic growth and wage can be expected to rise with time following the traditional growth theory [2]. Thus, it is expected that Bangladesh will move towards capital intensive heavy industry or new digitalization and new pattern of industrial growth to sustain its fast economic growth. However, COVID19 crisis and immediate impacts and possible changing global trade and labor rules will make it even more imperative for Bangladesh to revisit its structure of industrialization and domestic market expansion and shorter supply chain to make the economy resilient [23], [24]. Energy sector centric manufacturing and activity expansion on sustainable path can be a major growth driver in post pandemic recovery pathway for Bangladesh.

3.2 Energy Demand Growth and Fuel Mix: Comparative Analysis of Fast Growth Phase of the Asian Countries

The progress of energy sector has been a major determining factor for economic growth and development [25]. After independence in 1965, Singapore focused on the investment in oil refineries.

But diversification of manufacturing sectors led to gradual reduction in share of oil related products share in industrial GDP from 50.0% in 1974 to 18.3% in 2002 [26], [27]. During seventies and early eighties, the industrial structure of Singapore was transformed from labor intensive industry to high capital heavy industry. These capital intensive industries are heavy machinery industries, electronic industries, oil refineries and petrochemical industries that require more energy than the labor intensive light industry. Besides, to expand the service and tourism sector, Singapore prolongs working hour and makes the city brighter at night. In addition, people use more house space or more people use large space home. Household energy consumption increased for additional use of lighting, TV sets and other electrical appliances. Thus, the energy demand of Singapore is increasing extensively with significant increase of economic growth [15]. Energy demand and GDP growth of Singapore are shown in Figure 1.

From the Figure 1, it is clear that the main source of primary energy in Singapore continues to be imported oil. However, natural gas is penetrating slowly. Coal use since 2015 and renewables since 1990 are still almost negligible in terms of share in total energy.

In China to support the outstanding annual economic growth of 9.8% between 1978 and 2009, energy consumption increased from 571.4 to 2329.53 Mtoe with a rate of 5.87% annually [4], [28]. For economic expansion of China, it experienced relatively lower growth rate of energy requirement [29]. There are two reasons behind this. First one is the rate of industrialization and urbanization. And the second one

in the export driven economic growth and producing high energy consuming products. Population growth indirectly impacted energy consumption and use patterns. Economic transformation of China goes through a transition phase between primary and secondary/tertiary industries. The focus goes for the structural upgradation and optimization of the industries in China on export based light industry and tertiary industry. However, increased number of secondary industry including metal, automobile, chemical, textile processing etc. rose energy intensity in China [19], [30].

There is a dramatic increase in Chinese energy demand between the years 2001 to 2011. During this time, energy consumption rises at a rate of 9.05% with the GDP growth rate of 10.56%. There are two factors behind this enormous demand growth of energy: economic industrialization and rise of middle-income class. Almost half of the Chinese GDP comes from industrial sector and it consumes about 70% of total energy. Again, this industrialization leads to expansion of old cities and create new cities. Moreover, the industry dominated economic growth leads to increase average working wages that ultimately enlarge the size of middle-income class. While the middle income class was 10% of the total population in 2000, it became 40% in 2010. This income rise led to change in their consumption pattern. Thus, more people are moving towards urban life and have better access to energy that ultimately increases the energy consumption [31]. Energy consumption and GDP growth rates in China from 1965 to 2017 are shown in Figure 2.

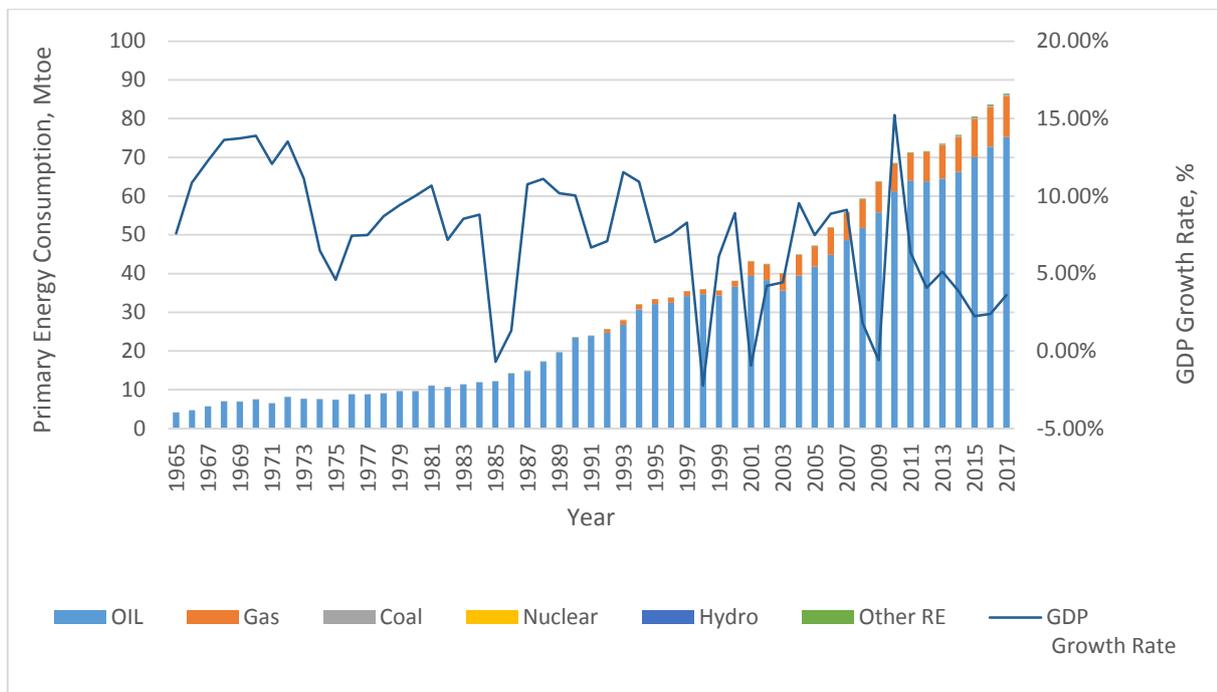


Fig. 1. Primary energy consumption by source and GDP growth of Singapore. (Source: [4], [28])

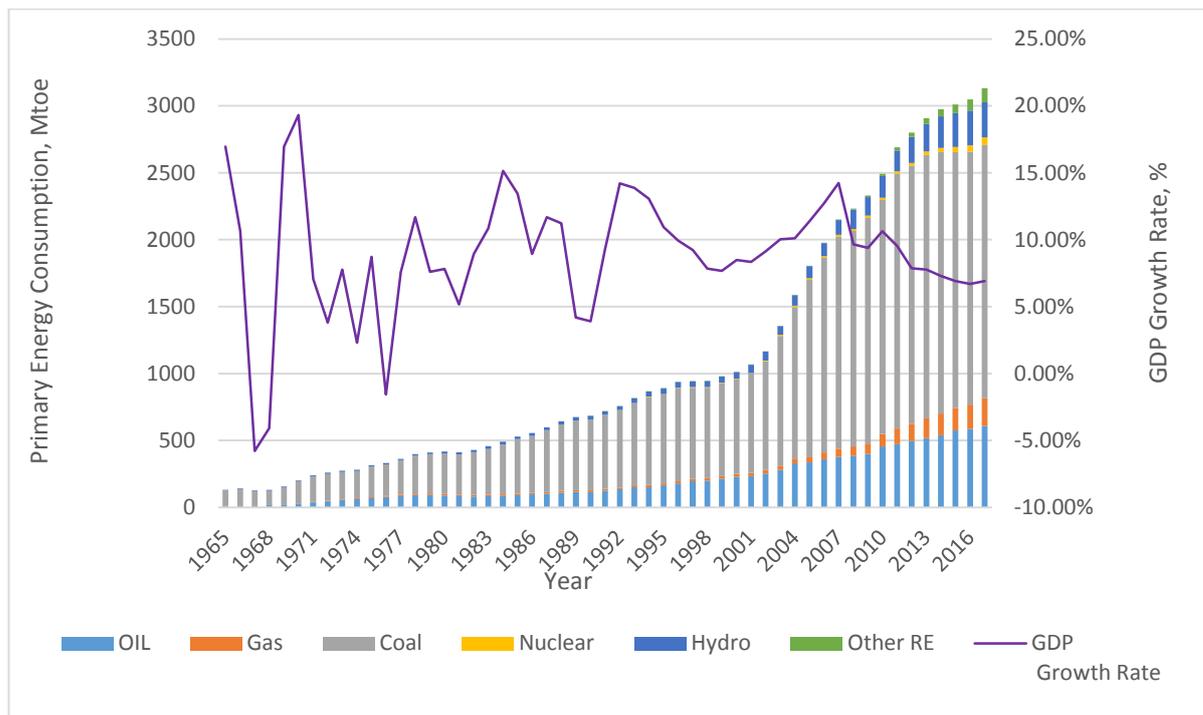


Fig. 2. Energy consumption and GDP growth rate in China between 1965 and 2017.

(Source: [4], [28])

Coal is still dominating as the source of primary energy in China and thus historically provides highest share of energy to support remarkable economic growth. During 1965 to 2017, coal share in total primary energy reduced from 87% to 50.6%, but supply of coal increases from 114 to 1893 Mtoe in the same period. Specially after the millennium, rapid economic growth, increased urbanization rate and energy shortage resulted in dramatic rise in the consumption of coal from 679 Mtoe in 2000 to 1914 Mtoe in 2015 with 7.2% annual growth rate. Oil is another important source of primary energy in China that has significant effect for accelerating its economic growth. After the reform program of economy in 1978, China experienced significant economic growth with improved living standard. As a result, the consumption of oil grew rapidly from 91 to 560 Mtoe between 1978 and 2015 with annual rate of 5%. But China did not have much reserve of oil and became crude oil net importer after 1993. Besides, continuous increase of economic growth with improved living standards resulted in significant development in automobiles and aviation sectors since 1990 that ultimately led to rise in oil consumption in China sharply. Thus, from 1965 to 2015, oil share in total consumed energy has risen from 8.3 to 18.6% [28], [32]–[34].

China has enormous reserve of natural gas resources, but the development of local natural gas industry is much slower. The government plan is to substitute coal by developing natural gas. Besides, energy production from nuclear source has risen significantly from 4.0 Mtoe energy production in 2001

to 56.2 Mtoe in 2017 at a rate of 28%. But still it accounts for only 1.79% of total national consumption.

China began to develop renewable energy since the world energy crisis in 1970s to accelerate the production of electricity from renewable source. This resulted into 5.5% share of consumed energy from renewable sources in 2004. During 2005–2009, significant support from the government made outstanding advancement of technology for renewable sources and increased the renewable energy consumption from 90.9 to 146.2 Mtoe with a rate of 10% annual growth. 11.41% of total energy is from renewable sources in 2017 with an amount of 368.25 Mtoe [28], [33], [35], [36].

Energy consumption of Malaysia also followed the same pattern with the economic growth. With rapid economic growth of 7.46% between 1965 and 1997, energy consumption growth was 9.45% and with moderate economic growth of 4.53% between 1998 and 2017, energy consumption growth was 4.72% annually [28]. The highest energy consuming sector is the transportation sector that accounts for 37% of total energy, followed by industry sector 28%, agriculture sector 17%, and residential sector 13% and non-energy use 20%.

Several energy policies have been implemented by the government to sustain rapid economic growth. National petroleum policy was implemented in 1975 for effective utilization of oil resource as oil was the main contributor of primary energy at that time. Aiming the long life of oil and gas reserves, national depletion policy was implemented in 1980. After that focus was on fuel divergence and policies were adopted in 1981

and 2002 respectively to overcome the dependency on oil and balancing the consumption of oil, natural gas, hydro, coal and renewables as primary source[37], [38].

In 1978, total primary energy supply was 8.352 Mtoe where 72.63% was provided by oil, followed by 24.2% from gas, 2.89% from hydro and 0.3% from coal. Primary energy supply and GDP growth of Malaysia from 1978 to 2017 are shown in Figure 3. The fuel diversification policy resulted in declining the share of oil supply in total primary energy. In 2017, natural gas and oil provides almost equally 36.96% and 36.99% of total energy respectively, followed by 20.08% from coal and the remaining from hydro and other renewables. (BP, 2018).

The country modified fuel diversification policy for many times to cope with the two international oil

crisis in 1973 and 1979. Overtime, the dependency on oil became lesser but at the same time to support its economic growth, the consumption of coal and natural gas increased significantly. The consumption of coal rises to 20.0 Mtoe in 2017 from 3.6 Mtoe in 2002 with an annual rate of 22.12% [28].

South Korea experienced remarkable GDP growth with annual average rate of 9.62% from 1965 to 1996 [4]. This growth was attained by transforming agriculture based economy to fully industrialized high tech economy. Initial focus was towards export based labor intensive industry to utilize low cost educated labor. But as the wage went up, labor intensive textile and footwear industry moved to steel and heavy industry in 1970s and to automobiles and electronics in 1980.

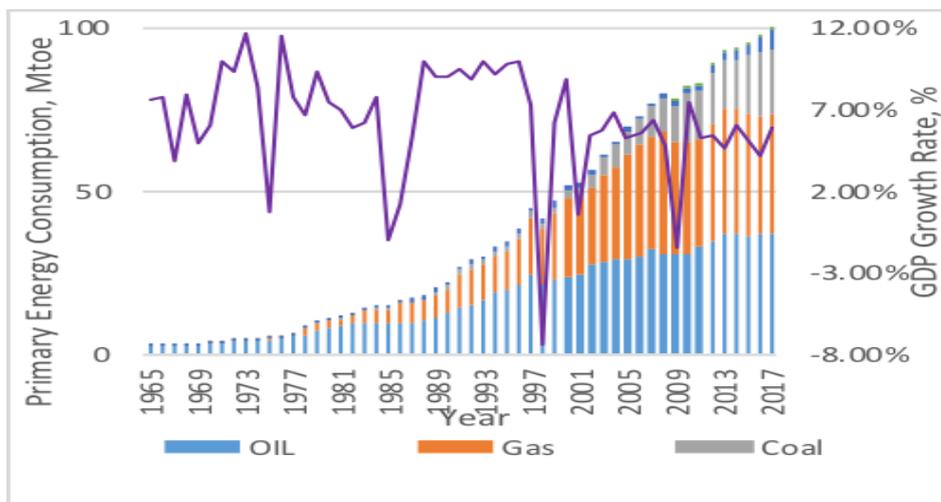


Fig. 3. Consumption of energy and growth rate of GDP in Malaysia between 1965 and 2017. (Source: [4], [28])

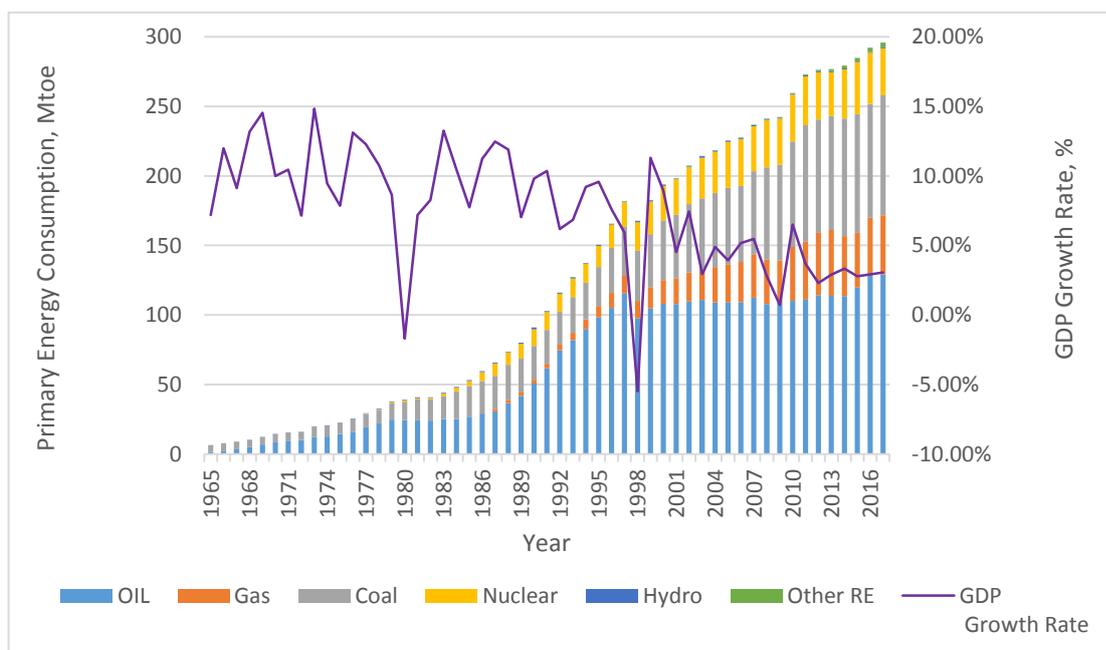


Fig. 4. Energy consumption and GDP growth in South Korea between 1965 and 2017. (Source: [4], [28])

Even with the limited resource, the rapid industrialization and economic growth over the last decades transformed it into a developed nation and in 1996 it joined OECD [17]. The primary energy supply and growth in consumption in South Korea from 1965 to 2017 are shown in Figure 4. Initially coal was the main source of energy. But with time, it went for oil, nuclear, gas and a small share of renewables to support its economic growth [28].

South Korea imports more than 95% of its energy. After the independence, it supported the industries that could replace import (1962-1967). Later, heavy chemical industries were supported in its five-year plan for the period of 1967 to 1971. During that time, imported oil was the major primary energy source and it was 58% of total primary energy consumption in 1970 with 40% coal and small share (2%) of hydro. After the Oil crisis in 1970, energy ministry targeted oil free policy to reduce oil share in total primary energy consumption and it went for nuclear power production in 1981 that has been increasing with time to support its economic growth. With higher economic growth, the country focused on energy efficiency improvement including distribution sector development and energy price adjustment for proper energy management that led to the reduction of energy intensity (energy

required/GDP) with a figure of 4% from 1983 to 1987 and 10.2% from 2000 to 2010. Furthermore, the country went for power market deregulation in 1990 and supported green energy in 2000 [39]–[41].

Bangladesh has experienced significant economic growth over last one decade. The structure of Bangladesh economy is moving towards non-agriculture based from agro-based economy although there is significant improvement in agricultural modernization. Energy demand of Bangladesh is also growing. During the year 2005 to 2017, while annual average GDP growth is 6.37%, the energy demand growth rate has been higher at 6.74%. Primary energy consumption increased from 16.1 to 33.0 Mtoe in the same period [1], [28]. Primary energy supply of Bangladesh are shown in the following Figure 5.

Bangladesh has increased the share of locally produced Natural Gas as primary energy source but the gas reserve is depleting fast [42]. Thus, to continue its high economic growth, nature of development of energy sector is going to be a vital driver. Now the question for Bangladesh is what should it prioritize: heavy industry (iron and steel, basic metal *etc.*) growth like China, Singapore, Malaysia, South Korea or grow with focus on new trend of future digitalized economy? Both needs energy in some form or the other.

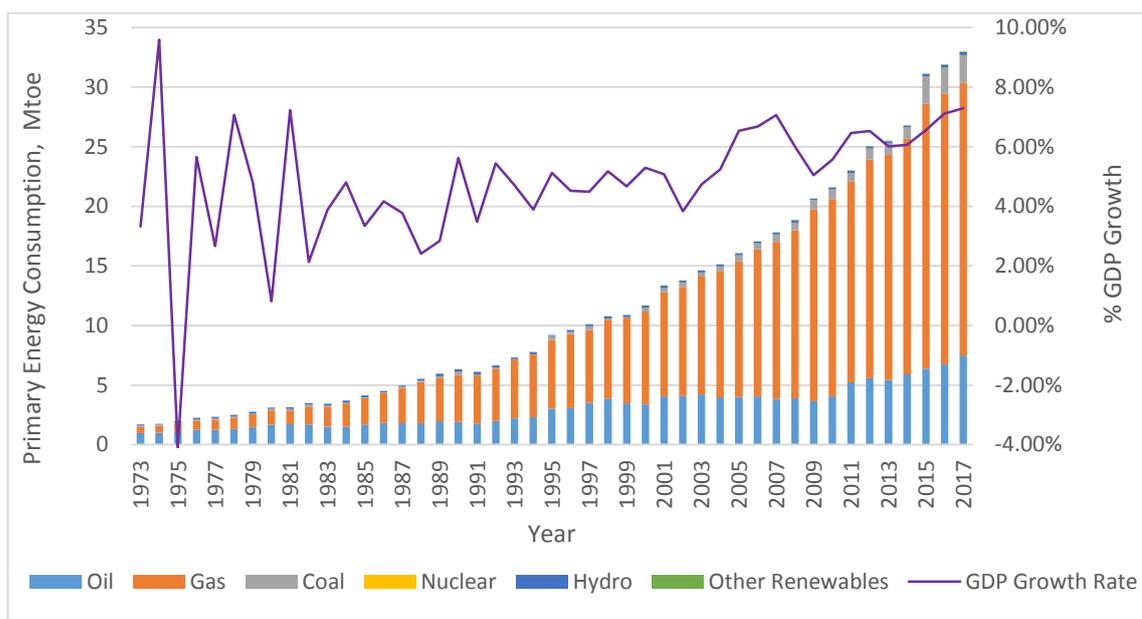


Fig. 5. Energy consumption and GDP growth in Bangladesh between 1965 and 2017.

(Source: [4], [28])

4. SUSTAINABLE ENERGY SECTOR DEVELOPMENT IN BANGLADESH: WINDOW OF OPPORTUNITY

In the past century energy sector development was mainly consistent with fast GDP growth. With changing paradigm of development in favour of sustainable development in this century energy sector also needs to

be synergistic with multidimensional targets of human wellbeing. United Nations Department of Economic and Social Affairs (DESA), International Energy Agency (IEA), Eurostat and European Environment Agency (EEA) produced a long list of indicators [43] for energy sector to be consistent with sustainable development. To ensure sustainable development, in 2015 all members of United Nations called for Sustainable Development

Goals(SDGs) that consist of 17 goals to ensure prosperity and peace for all people by 2030. These 17 SDGs are integrated action that balance social, economic and environmental sustainability. SDG 7 is to ensure access to affordable, reliable, sustainable and

modern energy. As the development is directly related to energy, SDG 7 is linked to all other SDGs and this interlinkage should be identified by the policy maker to make an SDG responsive energy plan and ensure sustainable energy development [44].

Table 4. Comparative analysis of energy, GDP growth rates and emissions in fast economic growth phase.

Country	Fast economic growth phase	Annual average growth rate (%)		Total CO2 emission, MT	Annual avg. CO2 emission per capita, MT	Energy sector
		GDP	Energy consumption			
Singapore	1965-1997	9.09	6.70	1,008,135	11.01	Imported and refined oil still dominate the energy sector. After 1991, imported natural gas has penetrated in the energy mix.
China	1978-2009	9.8	5.87	107,239,299	2.77	Heavy reliance on coal, gas, oil. Local coal provided the highest share of energy at 71% in 1978, 72% in 2009 and 60% in 2017. Oil share in energy mix was 23% in 1978, 17% in 2009 and 18% in 2018. With the development of local natural gas resource, its share in the energy mix increased significantly from 24.7 Mtoe in 2001 to 177.6 Mtoe in 2015 with a rate of 15.1%.
Malaysia	1965-1997	7.46	9.45	1,372,118	2.50	Before 1978, locally produced oil was fulfilling more than 90% of its energy demand. Natural gas became a significant source of energy since 1978. The total primary energy supply was 6.108 Mtoe in 1977 where 91.68% was provided by oil, followed by 4.47% from gas, 3.67% from hydro and 0.2% from coal.
South Korea	1965-1996	10.70	11.05	4,998,751	3.84	Coal was the main source of energy during its initial industrialization. In 1970, 59% of energy was supplied from oil, 39% from coal and the remaining 2% from hydroelectricity.
Bangladesh	2005-2017	6.37	6.74%	817,586	0.46	Bangladesh is a new fast growing economy. Locally Produced natural gas is the main energy source. The country started to import natural gas from 2018 to meet its growing demand. Imported and refined oil also provide significant amount of energy. Coal share is increasing since 2005. The energy mix was changed from 71% Gas, 25% oil, 3% coal, 1% hydro to 69.3% Gas, 22.69% oil, 7.09 % coal, 0.71% hydro and 0.3% renewables.

Source: Summary by authors from various sources mentioned in the text.

While Bangladesh adds new capacities in power sector and other energy service demands over next two decades it can align to satisfy multiple objectives under three broad categories: social, economic and environmental. In sustainable energy sector development, primary target of rapid energy supply growth is seen at the same level with significant energy efficiency improvement and energy security [45]–[47]. Unless enhanced supply is simultaneously synergistic with social goals of equity in access, affordability and environmental target of clean air, water *etc.* 21st century energy sector development will not be consistent with sustainability goal. These are also linked to high decent job creation target. Bangladesh economy now is trying to catch up with the similar pattern and rate of economic growth as other fast growing economic countries in the region during their rapid growth era of past century. Therefore, significant growth in energy sector is inevitable and needs to be assured.

As the country's domestic resource endowment of natural gas is depleting due to historical dependence and limited reserve, the country is currently struggling with the persistent problem of the gas based energy system and how to make transition more sustainable in future [48]. The major transition in energy sector to gas based energy sector happened in 1975 in Bangladesh with nationalization of the gas fields [49]. Extraction, transportation infrastructure, manpower development and institutions, regulatory mechanisms, price-subsidy all were centered around increasing penetration of gas in total energy mix as is already evident from Figure 5 above. A new transition now poses several challenges but expands opportunities also as major share of future energy supply will be built now and in coming decades. From multilevel perspective landscape level changes through adoption of global collective actions towards sustainability where Bangladesh is also a party [50], the pressure is building up for change. However, this is also, coinciding with national level need for diversification of almost monolithic natural gas dominated sector. So, the cheap fossil fuel driven faster economic growth of Asian tigers in the past century is an old narrative and is changing very fast (Figure 7). This change needs to be articulated to decision makers and political level to overcome the persistent problem of fossil fuel dependency. Once backstop technology wind and solar are competitive now in global market place in terms of levelised cost of energy (Figure 6).

In case of Bangladesh energy sector, as the electricity supply needs to increase in next two decades by a factor of 3, strategic action is necessary to diversify the sector in terms of primary energy sources. Current gas dependent regime can be diversified by increased penetration of new renewable energy sources and

technologies for meeting additional demand. This can provide opportunity for sustainable energy transition. The processes of change are represented conceptually in Figure 6.

However, national plan to diversify energy sector by introducing 50% of its power generation from coal and 10% of electricity generation from renewables by 2041 [52] is in contradiction with landscape level changes. Global assessment reports are assuming contribution of coal use without Carbon Capture and Storage or Use (CCS/U) to become zero as soon as possible to manage stabilization of global warming well below 2°C [53]. So new investment in coal power capacity needs to be revisited in the line of sustainable energy sector transition with new proven clean technologies. These are not only for power generation but includes both distribution sector and demand side planning. Modernization of fossil fuel era, digital advancement to enhance renewable energy penetration by massive revolutionary reforms in generation, distribution, consumption and smart production of energy through technologies like big data, IoT, cloud computing, block chain technology, smart grid, efficient energy storing are the emerging trends. Theoretically connecting all energy sectors like production, distribution, consumption and storage through intelligent network technologies bring the opportunity to overcome the imbalance of production and consumption easily [54]. However, feasibility and readiness of Bangladesh in terms of human capacity to integrate all these revolutionary changes need serious consideration or strategic action plan. Since, such digitalization for energy sector management needs reliable energy supply and manpower building, given the global sustainable goals and SDG 17 international cooperation, path needs to be chosen through appropriate institution building by the decision makers in Bangladesh. Bangladesh is a much advantageous position than other fast growing countries from past century as not the entire 100% of the country's energy sector is locked in fossil fuel path. If electricity sector needs to expand 3 times, then only 1/4th of energy sector *i.e.*, 25% of the future energy sector is currently locked-in on fossil fuel path. Increase in energy efficiency in end use sector and a variety of clean/renewable energy penetration for achieving SDG 7 target by 2030 provides enormous scope for Bangladesh to create employment in energy sector, opens up prospect of new business opportunities and manpower planning and education. This cannot be achieved without strategic sustainable transition planning for the energy sector through participatory process of engaging all actors likely to be involved in the process as shown in Figure 7.

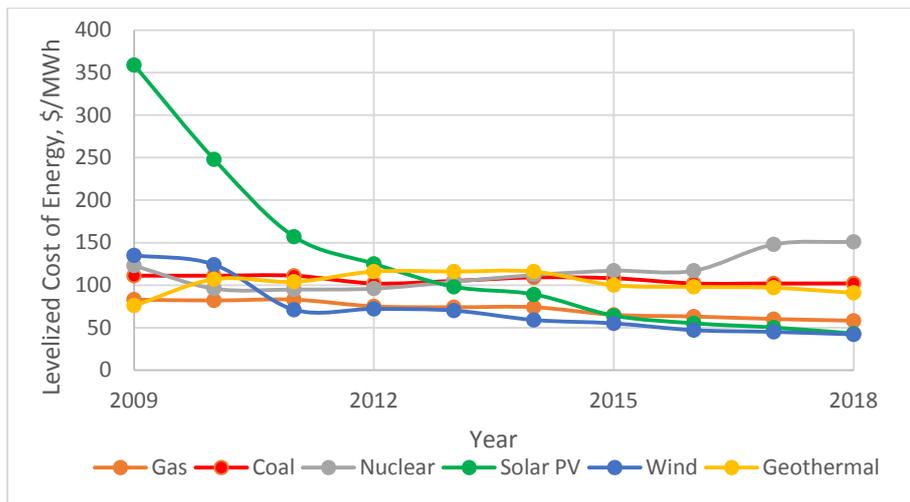


Fig. 6. Levelized cost of energy.

(Source: [51])

So which way forward for Bangladesh will depend on a successful strategic energy-power coupled sector growth planning. Also, with rising income and household appliance demand, residential electricity use is also predicted to increase. So, the question is what alternative options for Bangladesh to develop a sustainable energy sector that can lead to needed fast economic growth and provide adequate access to energy for all.

Bangladesh while taking off in next couple of decades can take advantage of global market developments in energy sector. The story line of cheap fossil fuels driven economic growth in the previous century is no longer valid (Figure 6). Renewable energy is getting cheaper very fast. With the possible future carbon price burden or the other constraints looming over fossil fuel sector, the relative cost is going to be even more favorable to renewables. Figure 6 shows how renewable energy is becoming economically competitive with alternative fuels. So, it is becoming clear that countries which will build path-dependency along cleaner fuel path will be the winner in this century.

5. CONCLUDING REMARKS

Economic structure is country specific, but the structural transformation of the fast growing Asian countries of past century followed almost homogeneous pattern of heavy industry growth led economic activity pattern fueled by fossil fuel. Initial growth phase was supported by agricultural modernization and import substitute industries. But with time, the contribution of agriculture sector was reduced and high growth came from export based labor intensive industry later transformed into capital intensive heavy industries. Next phase focused on service sector or light modern high-tech industry. The energy sources in this fast growth phase came from mostly local energy resources but was dominated by fossil sources which is still continuing to be the case.

Singapore's GDP grew 9.08% annually from 1965

to 1997 with the increase of 6.7% annual energy consumption. Oil dominated the energy mix. Chinese economy grew at 9.8% annually during 1978-2009. Energy consumption dominated by coal, oil and gas increased at a rate of 5.87% annually. Rapid economic growth of Malaysia at yearly rate of 7.46% from 1965 to 1997 resulted in significant rise of annual energy consumption at 9.45% during this period. South Korea achieved remarkable economic growth 9.62% annually from 1963 to 1996 that raised its annual energy consumption 11.05% during this period. Imported oil and coal were the main source of energy during its initial industrialization. Besides, the country also have focused on energy efficiency improvement including distribution sector and energy price adjustment for proper energy management since 1983. Each country had much higher per capita emissions levels during their fast growth phase compared to more recent fast growth phase of Bangladesh.

Bangladesh, with 6.37% GDP growth rate and 6.74% energy demand growth rate annually, is a new emerging country in this decade still with very low per capita emissions [4], [28]. The economy has moved to labor intensive export oriented industry sector during initial fast growth phase. Whether Bangladesh adopts heavy industry path or digitized economy path will have to very much depend on its sustainable energy sector plan given the changed global context and new opportunities. Bangladesh, in coming decades going to increase its power generation capacity three times from its current capacity, has the advantage to take the benefit of changing market condition and global cooperation in implementation of new renewable and cleaner fuel sources to sustain both the energy sector and the economy and low per capita emissions. This study gives rise to multiple research questions around setting up of priorities in achieving sustainability in energy sector faster, barriers to be overcome and deriving a road map with national future scenarios in vision.

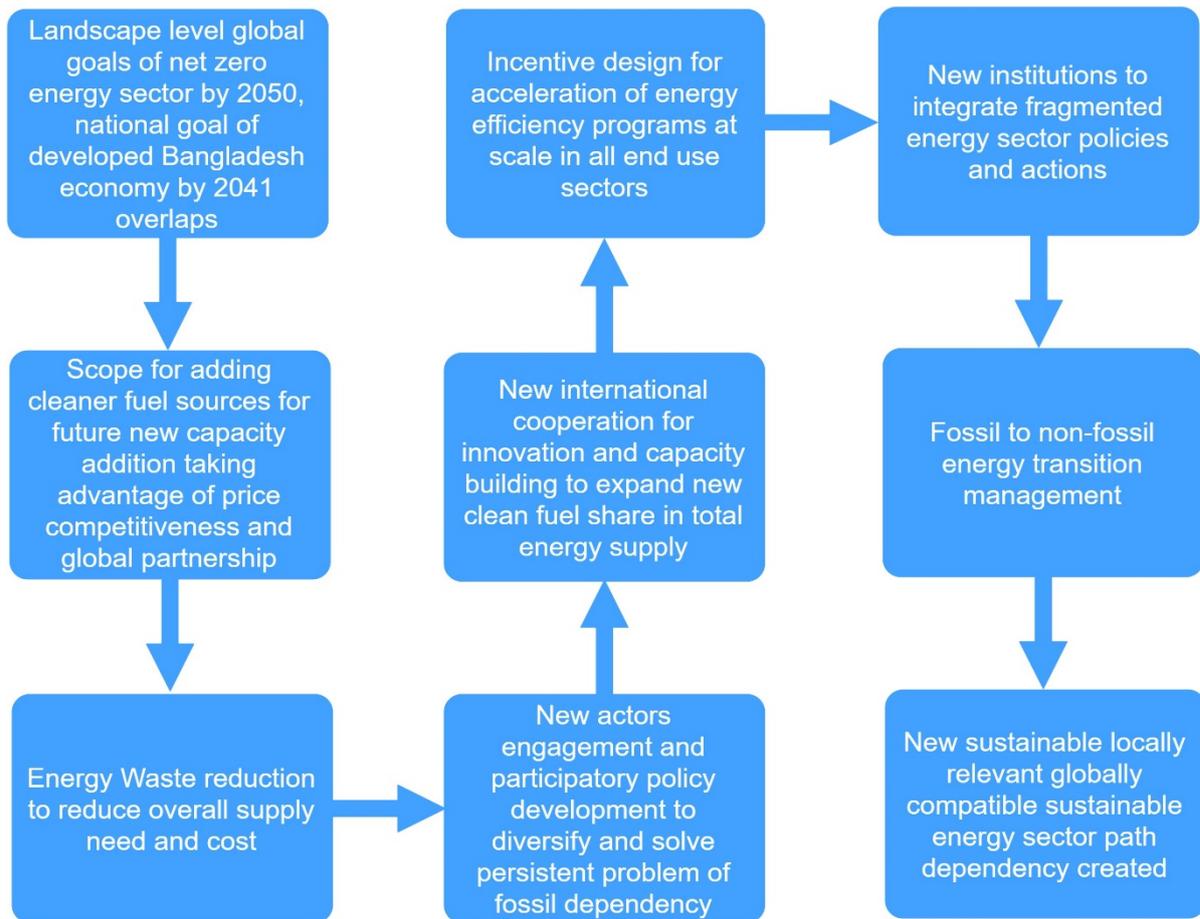


Fig. 7. Window of opportunity for Bangladesh in bending the process of change towards sustainable energy sector compatible with national and global goals.

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