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ESTIMATION OF HYDROGEN DEMAND POTENTIAL IN BANGLADESH BY 2030

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ABSTRACT

Due to the environmental deterioration, fossil fuels are no longer preferable energy sources. Among other alternatives, hydrogen is a potential candidate to replace fossil fuels. Some countries have already developed the hydrogen economy and policy. Many East Asian countries are to deploy the policy within 2040. Keeping pace with neighbours, Bangladesh should also establish a hydrogen economy and policy. For this, the projection of hydrogen demand is urgent. In this paper, performed analysis shows the potential of hydrogen demand by Bangladesh in 2030. The analysis is based on the assumption and criteria used by Economic Research Institute for ASEAN and East Asia for the report on Demand and Supply Potential of Hydrogen Energy in East Asia. There are three scenarios, each having a specific percentage of different fuel mix. These three scenarios are modified and set for Bangladesh. For scenario1, Bangladesh would require about 2.986 MTOE of hydrogen in 2030, whereas for scenario 2 and 3 the amount would be 5.996 and 9.014 MTOE. The Power sector would consume about 70% whereas industries and transport would consume 23% and 6%, namely. Technology transfer and locally developed low cost systems may facilitate more accessible and low-cost production of hydrogen in Bangladesh because of the penetration of Renewable energy sources and technologies. Technology transfer would be challenging for Bangladesh. As neighbouring countries have already completed, and about to start making hydrogen policy, Bangladesh should commence on it. This research would contribute to the hydrogen economy and policy in Bangladesh.

Keywords: Hydrogen Economy, Fuel Mix, Green Hydrogen, Demand, Technology Transfer

1. Introduction

Hydrogen is the cleanest and most environmentally safe fuel for the future. It has the potential to take over fossil fuels. However, much research and development are required to establish general purpose use of hydrogen as fuel. Many countries have already made policy on the hydrogen economy [1]. England, USA, Canada, Australia, Germany, Ireland, Japan, South Korea and China has accounted on hydrogen and invested millions of dollars on establishing the hydrogen economy [2]. Among them, Australia, India, China, Japan, and Korea has completed the formulation of hydrogen policy [3]. India and China are the close neighbours of Bangladesh. In contrast to them, there is no mentionable step taken here in Bangladesh. The country needs to complete a national Demand projection and identify sectors.

In Bangladesh, the pattern of fuel usage varies within a few numbers of sources. Electricity production is mostly dependent on natural gas. Here, the transport sector uses imported petroleum products. The indigenous natural gas reserve is depleting quickly. Bangladesh has started importing LPG to support increasing demands. So, the country is mostly dependent on energy imports other than for natural gas [4]. In future, it has to reduce the usage of natural gas to save the NG reserve as well as reduce the

petroleum usage to mitigate climate issues.

Like some other Asian countries, Bangladesh needs to step on finding reliable new energy sources and making proper policy. The demand and supply potential of East Asian countries are showing that this part of the world is revising energy policy and choosing hydrogen as a fuel mix [5]. Though most of the countries are yet to complete the policy [6], it is high time for Bangladesh to start on it. To make a proper hydrogen policy, Bangladesh needs to exercise on its future demand. This research aims to calculate demand projection in 2030 to contribute to the need.

2. Methodology

In this research, identifies the current scenario of energy usage in Bangladesh. The analysis uses the sector-wise consumption of petroleum products and natural gas. It also deals with data from published documents and reports of the Bangladesh Government. Future demands are estimated based on the projected values by the reports [7]. Economic Research Institute for ASEAN and East Asia published the report on Demand and Supply Potential of Hydrogen Energy in East Asia in May 2019. In this report, the estimation is mainly in three sectors. Electricity generation, transport and industrial sectors are the most prominent fuel users. So the analysis deals with these sectors based on three energy mix scenarios. They have set several goals for three sectors. In this research, some assumptions and goals are modified to match a close fit for Bangladesh. For East Asian Summit (EAS) region countries, it is set that 20% of new coal-fired electricity generation would be converted to natural gas and H2 mixed fuel-fired generation within 2040 [8].

20% of new natural gas-fired electricity generation would be converted to natural gas and H2 mixed fuel-fired generation. 20% of natural gas consumption for industrial purposes would be replaced by natural gas and H2 mixed fuel.

For transport, a percentage of Gasoline demand would be converted into H2 by introducing new vehicles that consume hydrogen. Similarly, Diesel demand would be converted to H2 and Diesel consumption for rail transport would be converted to H2. The target is set for 2040. Table 1 shows the categorized assumptions and fuel mix scenarios for EAS countries. In this research, the hydrogen demand for Bangladesh is estimated for 2030. The goals are set to half in each case of EAS to estimate for Bangladesh. Bangladesh would be in similar consideration as like as an Organization for Economic Co-operation and Development (OECD) countries [9].

Table 2 shows the categorized assumptions and fuel mix for Bangladesh up to 2030. Coal-fired plants are not considered; instead, petroleum-based power generation is taken into account. In the transport sector, diesel-based vehicles are to be converted into petroleum and hydrogen-based technologies. For EAS countries it has been assumed that trains would be remaining on diesel with the fuel cell technology. For Bangladesh, railway locomotives are not considered here rather other transport would share gasoline and fuel cell-based technology.

In Table 3, biomass is presented though, is it not considered as the commercial energy. It presents the overall demand and usage, including the commercially available and non-commercial form of energy sources. The total commercial energy usage in 2017-2018 is 33.4 MTOE [11].

It has been observed that nearly 65% of commercial energy usage is natural gas, and 21% is fossil fuel oil. Indigenous natural gas resources are depleting. It has been projected that natural gas production would be 63.69 Bcf in 2040, whereas about 960.77 Bcf was produced in 2017-2018 [12]. The rate of depletion is alarming. So Bangladesh needs to reduce the use of its natural gas reserve to slower the depletion rate. LPG has come into the scene recently as a substitute for natural gas. New fuel mix technology is a must to help the situation.

3. The current demand for a different type of fuel in Bangladesh

In Bangladesh, fossil fuels are the major components for meeting energy demands. It includes petroleum products like octane, petrol, diesel, kerosene, coal, liquid petroleum gas (LPG), natural gas, biomass. A small portion is sourced from Renewable Energy (RE) sources like solar, wind, hydro. In recent years, Bangladesh has started importing electricity. Here, Fossil fuels are mainly managed by import though it has natural gas and coal mines. In the 2017-2018 fiscal year, estimated usage of energy was 47 metric ton oil equivalent (MTOE) [10]. Bangladesh has the lowest per capita energy usage among the South Asian countries; 293 kgOE. Per capita generation of electricity is 446 kWh [11].

3.1 Sector-wise current usage of different fuels

There are four significant sectors identified that hold the capital share of gross energy demands of the country. Power generation, transport, agriculture and industrial sectors are the main consumers. The focus of this research is the projection of petroleum and natural gas demands. Table 2 shows the sector-wise usage of petroleum and natural gas in the year of 2017-2018. The power sector is the primary user of natural gas. About 64% is consumed here [13]. After the power sector, the use of natural gas in industries and households are remarkable. Though new gas line connection towards home users are not being facilitated, still it has a 16% share whereas industries have 17%. Petroleum products are mainly used in the transport sector, having 50% of its national demand [14].

4. Projected demand potential in 2030

Report on Energy Scenario Bangladesh 2017-18 published by Hydrocarbon Unit, Energy and Mineral Resources Division, Ministry of Power, Energy and Mineral Resources in January 2019 presents the Energy demand potential in 2030. It has predicted that natural gas demand would be about 8000 MMscfd in 2030, which is nearly 2920 Bcf. On the other hand, total petroleum demand would be 10 M metric Tonnes. Sector-wise future demand is obtained and presented in Table 5, highlighting the share of each fuel. Accepting that there would be no significant changes within 10 years' time period. Bangladesh government is

planning to reduce the supply of natural gas toward captive power plants and increase supply to public and private power plants along with industries. Assuming that about 6 % would be reduced in captive and 4% would be increased in domestic and 2% in industries within 2030.

In Bangladesh, among other petroleum products, furnace-oil and diesel are also used in power production. In data analysis furnace oil and diesel is considered together and mentioned as oil in Table 7. In 2018 fuel oil demand of the power sector is about 1.86 MTOE, which might reach up to 2.6 MTOE in 2030. Natural gas demand would be nearly 39 MTOE. In the transport sector, 1.01 MTOE would be increased from the current requirement. In Table 6, sector-wise demand projection is presented by fuel type.

4.1 Demand potential of Hydrogen in 2030

In 2030 the energy demand is assumed to be supplied from several mixes of fuels. In the power sector, fuel oils would be mixed with hydrogen gas to reduce its consumption. Similarly, the natural gas consumption would be reduced by hydrogen mix.

In the transport sector, according to EAS assumption, all diesel vehicles would be replaced by gasoline and hydrogen mix. In Bangladesh, CNG is used in the transport sector. It has been considered for replacing a part by fuel cell vehicles and maximum by the gasoline vehicles to reduce the use of natural gas in the transport sector. Some part of existing gasoline vehicles would be replaced by FCVs also. There are three scenarios in EAS assumptions. By scenario 1, total demand for hydrogen would be 2.99 MTOE which is the lowest among all other scenarios. The third scenario results in 9.014 MTOE. Hydrogen demand would be highest in the power sector. It is expected to be 70%. Industries would have approximately 23%, and transport would have nearly 6% of the gross. There might be other commercial and non-commercial aspects of hydrogen but exempted from this research.

In scenarion1 power sector gasoline usage to be replaced by 5% hydrogen and 95% petroleum, In scenarion2 power sector gasoline usage to be replaced by 10% hydrogen and 90% petroleum, In scenarion3 power sector gasoline usage to be replaced by 15% hydrogen and 85% petroleum.
In scenarion1 power sector, natural gas usage to be reduced 5% by hydrogen by using a mix of 5% hydrogen and 95% natural gas. In scenarion2 power sector natural gas usage to be replaced by 10% hydrogen and 90% natural gas and In scenarion3 power sector natural gas usage to be replaced by 15% hydrogen and 85% natural gas. These considerations are the same for the industrial and transport sector natural gas usage.

In transport scenario 1, 2 and 3 are set to replace pure gasoline by a mix of petrol and hydrogen. These are namely 0.5% hydrogen with 99.5% petrol, 2.5% hydrogen with 97.5% petrol and 5% hydrogen with 95% petrol. Here, Scenario 1, 2 and 3 are set to replace pure diesel by a mix of petrol and hydrogen. These are namely 0.0125% hydrogen and 99.9875%

petrol, 0.025% hydrogen 99.975% petrol and 0.05% hydrogen 99.95% petrol.

In scenarion1 transport sector, natural gas usage scenarios are the same as the power sector.

The demand would be based on technology transfer at the user end. In the power sector, Hydrogen and natural gas mixed fuel gas turbine would replace the conventional gas turbines. Hydrogen and natural gas mixed fuel large and small scale boilers would be used in various industries as well as in power plants. Fuel cell vehicles and Fuel cell buses would be used in the transport sector. These technologies would create the demand for hydrogen in future.

5. Scopes and Challenges

Due to the climate issues the entire world is facing, fossil fuels are no more the noble choice. Most advanced countries are rushing toward the green fuel solutions. Above all, hydrogen is the most prominent solution up to date. But there is some technological barrier towards establishing the hydrogen economy for any country. First of all, it requires energy input to produce. There are some technical issues for the storage also. There are several established methods of hydrogen production; each of these has different categories of issues; however, electrolysis and biomass gasification might be suitable for Bangladesh [15].

In Bangladesh, solar photovoltaic technology is being exploited in the form of small and large scale applications. Availability of solar radiation is adequate here. The price of renewable electricity has been lowered by government policy. Electricity can be used to produce hydrogen to store energy as well for various commercial and non-commercial use of hydrogen. Price of hydrogen is a barrier to expand its use. Large scale photovoltaic technology based hydrogen production might result in a competitive market price of hydrogen, which may help Bangladesh becoming a green hydrogen producer. To full fill that low price locally developed electrolyzers can play a vital role. Japan imports hydrogen from other countries currently from Australia [16]. Likewise, Bangladesh may also export green hydrogen to other countries.

Current technologies need to be changed, added and modified to use hydrogen domestically. Using natural gas and hydrogen mix fuels in boilers and gas turbines shows prospective results. It has a safe range of mix ratio, which is 8:2. Research is going on to increase it up to 7:3. In this ratio, NOx formation has been identified, and mitigation method is also developed. However, the technology is still in development phase. In the transport sector, FCVs can be launched, but in that case, hydrogen filling stations are to be established first.

6. Conclusion

Having potential in the renewable energy sector, especially in solar, Bangladesh can become a prominent producer of green hydrogen in the Asian region. As many neighbouring countries in the same region are trying to establish the hydrogen economy, Bangladesh should step forward to achieve the same. A very few countries have already completed the documentation for the hydrogen policy like India and China, but most of the cases

it has not yet been started. However, most of the countries have set the timeline and had the hydrogen demand projection for 2040. As Bangladesh has energy demand projection up to 2030, the hydrogen demand for 2030 is predicted by this work. If technology transfer and adaptation toward the hydrogen economy is accepted here, the power sector would require the most of it as the form of commercially available hydrogen. Along with, the industrial and transport sector would experience the demand for this clean fuel as a fuel mix in 2030. Hydrogen would reduce the gross usage of fossil fuels and help to fight the climate issue more firmly. The demand projection is based on some specific assumptions and some current plans of the government. However, the approach can be taken into account, and many other sector-specific considerations can be incorporated to it for a closer projection. Still, this work can contribute to make hydrogen policy in Bangladesh and provide some information based on specific scenarios on demand in 2030.

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Table 1. Estimation parameters of East Asian Countries for 2040

Sector	Fuel	Scenario 1	Scenario 2	Scenario 3
Power	Coal	H2: 10% NG: 90%	H2: 20% NG: 80%	H2: 30% NG: 70%
	NG	H2: 10% NG: 90%	H2: 20% NG: 80%	H2: 30% NG: 70%
Industry	NG	H2: 10% NG: 90%	H2: 20% NG: 80%	H2: 30% NG: 70%
Transport	Petrol	**OECD** H2:2.0% Pet: 98% **Non-OECD** H2: 1.0% Pet: 99%	**OECD** H2:10% Pet: 90% **Non-OECD** H2: 5% Pet: 95%	**OECD** H2:20% Pet: 80% **Non-OECD** H2: 10% Pet: 90%
	Diesel	**Japan** H2: 0.05% Pet: 99.95% **Other** H2: 0.025% Pet: 99.975%	**Japan** H2: 0.1% Pet: 99.9% **Other** H2: 0.05% Pet:99.95%	**Japan** H2: 0.2% Pet: 99.8% **Other** H2: 0.1% Pet:99.99%
	Diesel	H2: 5% Diesel: 95%	H2: 10% Diesel:90%	H2: 20% Diesel: 80%

Table 2. Estimation parameters for Bangladesh for 2030

Sector	Fuel	Scenario 1	Scenario 2	Scenario 3
Power	Gasol.	H2: 5% Pet: 95%	H2: 10% Pet: 90%	H2: 15% Pet: 85%
	NG	H2: 5% NG: 95%	H2: 10% NG: 90%	H2: 15% NG: 85%
Industry	NG	H2: 5% NG: 95%	H2: 10% NG: 90%	H2: 15% NG: 85%
Transport	Gasol.	H2: 0.5% Pet: 99.5%	H2: 2.5% Pet: 97.5%	H2: 5% Pet: 95%
	Diesel	H2: 0.0125% Pet: 99.9875%	H2: 0.025% Pet: 99.975%	H2: 0.05% Pet:99.95%
	NG	H2: 5% NG: 95%	H2: 10% NG: 90%	H2: 15% NG: 85%

Table 3. Energy calculation for 2017-18. (MTOE) source (Energy Scenario Bangladesh 2017-18 published by Hydrocarbon Unit, Energy and Mineral Resources Division, Ministry of Power, Energy and Mineral Resources)

Name of Fuel	Unit	MTOE
Oil (Crude, Refined, LPG) in K ton	6948	6.9
LPG	554	0.5
Natural Gas in Bcf	961	22.3
Coal (Imported) in K ton	3395	2.1
Coal (Local) in K ton	923	0.6
RE (Hydro) in MW	230	0.2
RE (Solar) in MW	350	0.3
Electricity (Imported) in MW	625	0.5
Subtotal		33.4
Biomass		13.6
TOTAL		47

Table 4. Petroleum and natural gas usage in 2017-18.

Sectors	Fuel Type	Unit	%
Power Sector	Petroleum	1871756 MT	26.94%
	Natural Gas	384.4 Bcf	40%
	Natural Gas (Captive Power)	153.76 Bcf	16%
Transport	Petroleum	3432239 MT	49.40%
	Natural Gas (CNG)	48.05 Bcf	5%
Industries	Petroleum	337903 MT	4.86%
	Natural Gas	163.37 Bcf	17%
Agriculture	Petroleum	1090903 MT	15.70%
	Natural Gas (fertilizers)	48.05 Bcf	5%
Household	Petroleum	156756 MT	2.26%
	Natural Gas	153.76 Bcf	16%
Other	Petroleum	58779 MT	0.84%
	Natural Gas	9.61cf	1%

Table 5. Sector-wise demand by fuel type in 2030.

Sectors	Fuel Type	Unit	%
Power Sector	Petroleum	2694000 MT	26.94%
	Natural Gas (domestic)	1284.8 Bcf	44%
	Natural Gas (captive)	292 Bcf	10%
Transport	Petroleum	4940000 MT	49.40%

	Natural Gas (CNG)	146 Bcf	5%
Industries	Petroleum	486000 MT	4.86%
	Natural Gas	554.8 Bcf	19%
Agriculture	Petroleum	1570000 MT	15.70%
	Natural Gas (fertilizers)	146 Bcf	5%
Household	Petroleum	226000 MT	2.26%
	Natural Gas	467.2 Bcf	16%
Other	Petroleum	84000 MT	0.84%
	Natural Gas	29.2 Bcf	1%

Table 6. Increase in fuel demand from 2018 to 2030

Sector	Fuel	Demand in 2017-2018 (in MTOE)	Demand in 2030 (in MTOE)
Power	Diesel + Furnace	1.86	2.6
	Natural Gas	12.49	39.42
Transport	Diesel	2.3	3.31
	Gasoline	1.1	1.63
	Natural Gas	1.12	3.65
Industries	Natural Gas	3.79	13.87

Table 7. Demand potential of Hydrogen in 2030 (in MTOE)

Sector	Scenario 1		Scenario 2		Scenario 3	
Power	**Oil**	**H_2**	**Oil**	**H_2**	**Oil**	**H_2**
	2.47	0.13	2.34	0.26	2.21	0.39
	NG	**H_2**	**NG**	**H_2**	**NG**	**H_2**
	37.449	1.971	35.478	3.942	33.507	5.913
Transport	**Diesel**	**H_2**	**Diesel**	**H_2**	**Diesel**	**H_2**
	3.309	0.001	3.309	0.001	3.308	0.002
	Gasol.	**H_2**	**Gasol.**	**H_2**	**Gasol.**	**H_2**
	1.622	0.008	1.589	0.041	1.549	0.082
	NG	**H_2**	**NG**	**H_2**	**NG**	**H_2**
	3.468	0.183	3.285	0.365	3.103	0.548
Industries	**NG**	**H_2**	**NG**	**H_2**	**NG**	**H_2**
	13.177	0.694	12.483	1.387	11.789	2.081
Total		2.986		5.996		9.014

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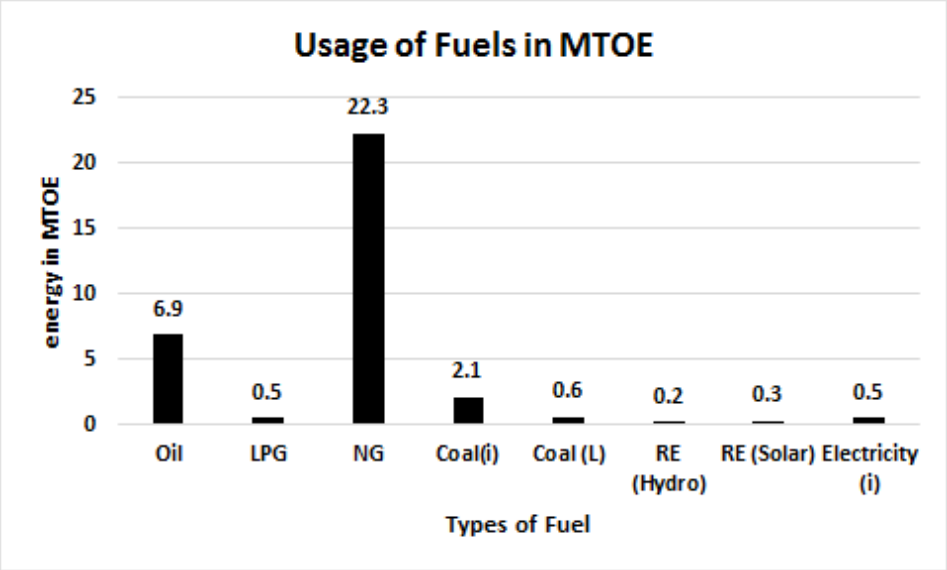

figure 1. Total usage of commercial energy in 2017-2018

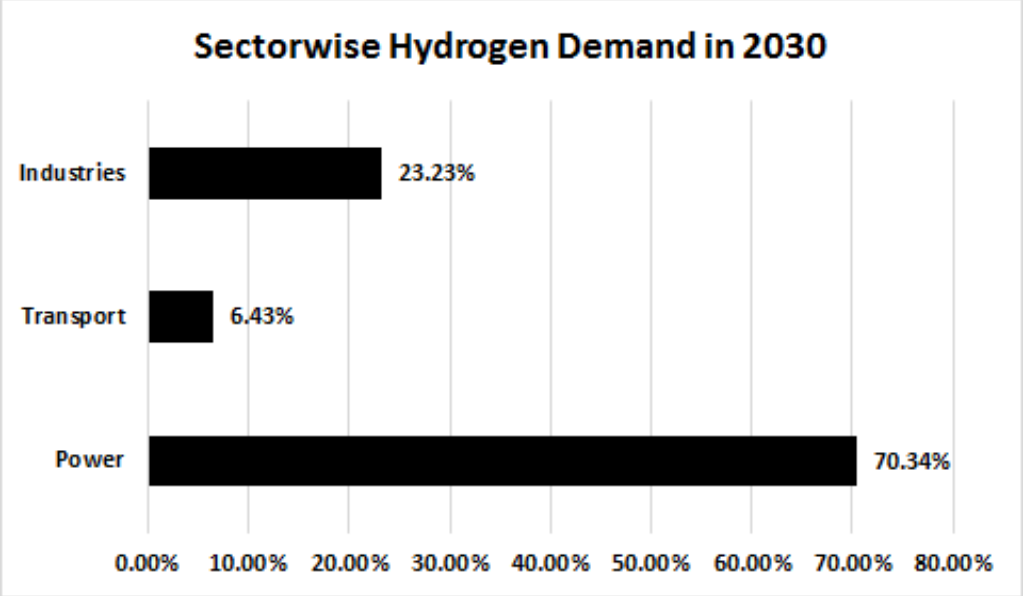

figure 2: Hydrogen demand potential in 2030 by sector