Coal Vs LNG based Power Generation and Challenges ahead of the Predicted Climate Issues by end of the 21st Century: Sri Lankan Context

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Abstract— *Since the industrial revolution that took place in 18th and 19th centuries, here in 21st century world is facing climate changes due to the substantial increase in the CO_2 concentration in the atmosphere. World population which was about 1 billion people in 1800 has risen to 7 billion by 2010 and estimated to cross the 10 billion mark by 2050! The people have become electricity intensive over the years and by today, a life without electricity is unimaginable.*

Intergovernmental Panel on Climate Change (IPCC) has estimated that by year 2011 anthropologic activities have released 1900 billion tons of CO_2 (equivalent) to the atmosphere and if by the end of 2100 the total emissions are not restricted to 2900 billion tons, the global average temperature increase by the end of this century will be in excess of 2C°; and if that is the case, there will be unimaginably catastrophic impacts on the existence of many civilizations around the world. The present emission rates of CO_2 are in the range of 40 billion tons a year and at this rate, the balance quota of 1000 billion tons of CO_2 will be gone in 25 years!

Many environmentalists have called for the world to switch to renewables immediately. There are giant steps taken in this regard in the renewable sector but in view of the huge demand on energy, these steps are too small to have any impact in containing the global average temperature increase by end of 2100 to 2C°. The technical challenges in harnessing renewable energy due to its intermittent and seasonal nature are yet to be overcome and electricity storage technologies, specially battery technologies have to become more technically and commercially viable.

Coal has been used for power generation over a long period of time and world is using over 7000 million tons of coal every year. Burning coal is blamed as the main reason for the emission of CO_2 to the atmosphere. A discussion has arisen in Sri Lanka whether country's electricity generation should switch from coal to LNG in view of the threats posed to the existence of the human beings due to the adverse environmental impacts of climate change.

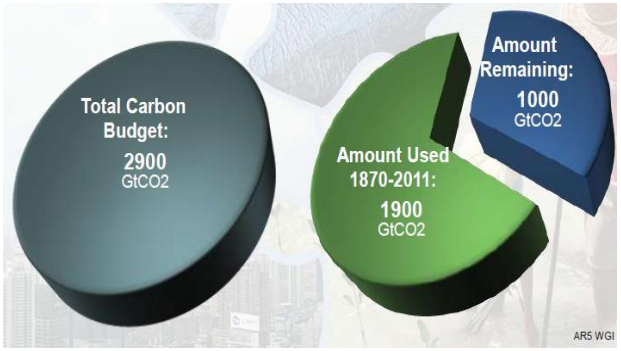
This paper discusses the relative position of Sri Lanka in regard to current and past GHG emissions, its international obligations and the possible impacts of the decision to switch from coal to LNG for power generation on the economic development of Sri Lanka.

Keywords: Coal, Liquefied Natural Gas, Green House Gasses

I. INTRODUCTION

Since the industrial revolution that took place in 18th and 19th centuries, today in 21st century, world is facing issues due to climate change arising from the substantial increase in the CO_2 and other Green House Gas (GHG) concentration in the atmosphere. World population which was about 1 billion people in 1800, has risen to 7 billion by 2010 and estimated to cross the 10 billion mark by 2050, even under medium growth scenario! The people have become energy and electricity intensive over the years and by today, a life without electricity or petroleum oils is unimaginable.

Until two decades back, talk was about development projects, their costs, implementation periods etc., but the word "Sustainable" was missing. It was after the scientists showed in the latter part of 20th century that the most likely reason for warming of the globe is due to the Green House Effect caused by the Green House Gasses (GHGs) that the whole world began to think the necessity to go "Sustainable".

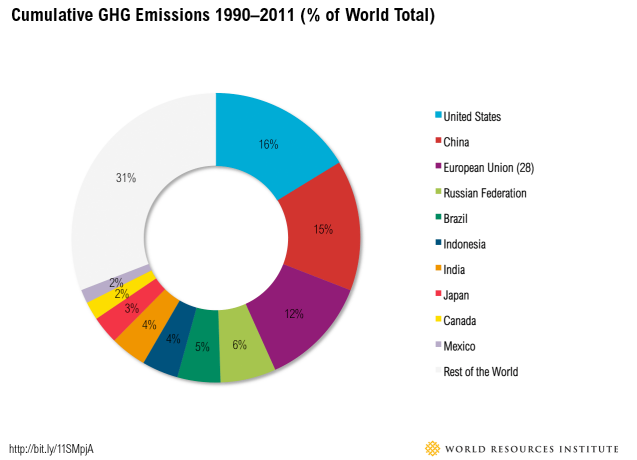


Source: ipcc.ch

Figure 1: **65% of our carbon budget compatible with a 2°C goal already used**

Intergovernmental Panel on Climate Change (IPCC) has estimated that by year 2011, anthropogenic activities have released 1900 billion tons of CO_2 (equivalent) to the atmosphere and if by the end of year 2100, the total emissions are not restricted to 2900 billion tons (Figure 1), the global average temperature increase by the end of this century will be in excess of 2C° ; and if that is the case, there will be unimaginably catastrophic impacts on the existence of many civilizations around the world. The present emission rates of GHGs are in the range of 40 billion tons a year and even at this rate the balance quota of 1000 billion tons of CO_2 will be gone in less than 25 years!

The larger portion of the world's population are in the developing countries, mainly in Asia where the poverty levels are high, per capita income is low, energy consumption is low and so on. So, is it fair or realistic that the burden of the reducing GHG emissions are put on these poor nations while developed world is the real emitter (Figure 2)? As mentioned earlier 1900 Billion tons of GHGs have already been emitted to the atmosphere by the developed countries. Is it meaningful and sensible to try to reduce, for example, Sri Lanka's annual GHG emission from 18.8 million tons a year with a per capita emission of 0.8 tons, by say 50% to 9.4 million tons while USA is emitting 6650 million tons with a per capita emission of 17.9 tons (Table 2)?



Source: iea.org

Figure 2 – Top 10 Emitters

On the other hand, the major impacts of climate change will be on the poor nations. Flash rains, flash floods, hurricanes, sea level rise, all these will affect poorer nations more. Thus the developing nations are left in a dilemma what to do. Reduce emissions, go for expensive renewable energy technologies and sacrifice economic development? Or Keep on emitting on business as usual and suffer almost the same consequences?

Among all these uncertainties, there is one answer. If global warming is to be contained, the developed nations who have contributed significantly to the already emitted GHG's should adequately compensate because for poor nations, it is unaffordable and unrealistic. These compensations can come in several different ways; drastically reducing their present emissions, switching to renewable energy in large scale, giving high carbon prices to the developing countries to compensate for the already emitted GHGs, are some of them.

II. ENERGY EFFICIENCY

Another useful approach, both the developed as well as the developing nations can adopt, is the increase of energy efficiency in all aspects. This can come as both supply side efficiency improvements and demand side efficiency improvements. International Energy Agency's (IEA) World Energy Outlook Climate Special Report 2016, suggests that under the Bridge Scenario, the GHG peaking can occur as early as 2020 and out of the estimated 5 billion tons per annum reduction, 50% need to come from energy efficiency measures (Figure 3).

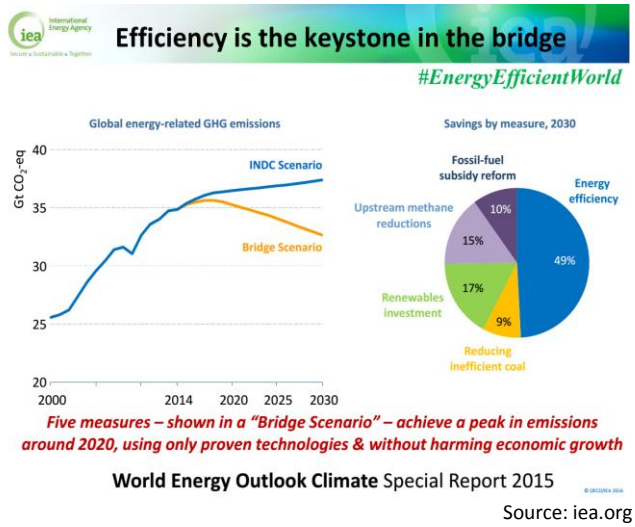


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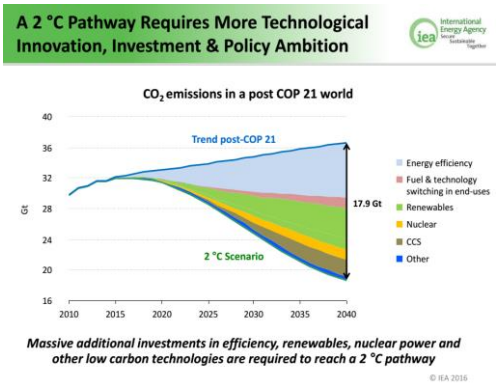
Figure 3

Figure 4 shows the GHG emissions reduction expectations of COP21. Now the question is who is going to do what? at what cost? where? and when?



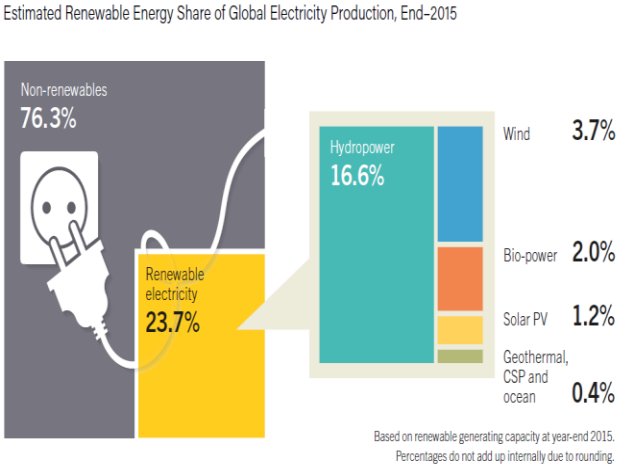
Source: iea.org

Figure 4: GHG emissions reduction expectations of COP21

III. RENEWABLE ENERGY

Many environmentalists have called for the world to switch to renewables immediately. There are giant steps taken in this regard in the renewable sector but in view of the huge demand on energy, these steps are too small to have any impact in containing the global average temperature increase by end of 2100 to 2C°. The technical challenges in harnessing renewable energy due to its intermittent and seasonal nature are yet to be overcome and electricity storage technologies, specially battery technologies have to become more technically and commercially viable.

Over the last decade, vast strides have taken in reducing both solar panel prices as well as the wind turbine prices. However even at the end of 2015, the total contribution from renewables for electricity generation was only 23.7 and the contribution from Solar PV was a mere 1.23% (Figure 5).



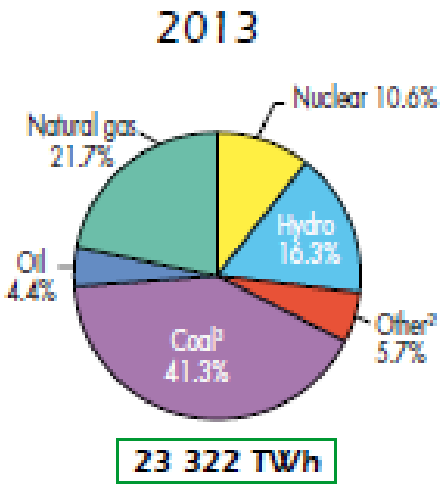
Source: iea.org

Figure 5: World Renewable Energy Share 2015

IV. COAL POWER GENERATION

Coal has been used for power generation over a long period of time and world is using over 7000 million tons of coal every year. Figure 6 shows how the electricity was generated in the world in year 2013.

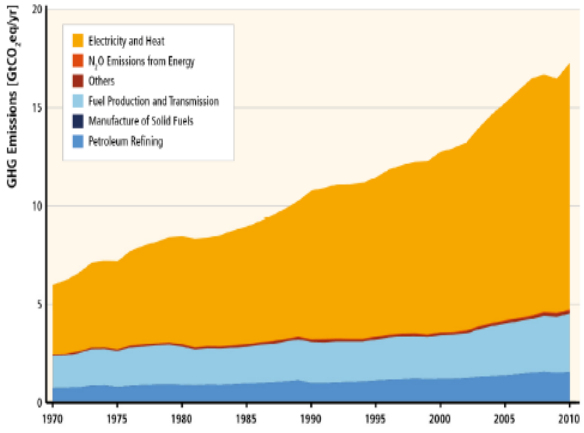
41.3% of the total electricity generation of 23322 TWh was generated from coal while 21.7% was generated by Natural Gas. Nuclear generated electricity was 10.6% and Hydro power generation was 16.3%. Renewable other sources contributed only 5.7% while Oil based electricity was only 4.4%. Thus 67.4% of electricity in 2013 was based on fossil fuels. Coal has been preferred for electricity generation mainly due to its cheapness compared to all other forms of fuel.



Source: iea.org

Figure 6: World Electricity Mix

Figure 7 shows the contributions made by different sectors to emission of GHGs. It is clear that electricity sector is the main contributor.



Source: ipcc.ch

Figure 7: GHG Contribution

Coal power plants have historically been low efficient. One reason for this is the fact that coal is cheap and until end of the 20th century, global warming and its relation to CO_2 emissions had not been established. In late years, special efforts have been taken to introduce high efficient supercritical and the ultra-supercritical coal power plants. Table 1 shows summary of different types of coal power technologies. Thus one option available for the entire world is to switch to high efficient coal power plants as a medium term solution.

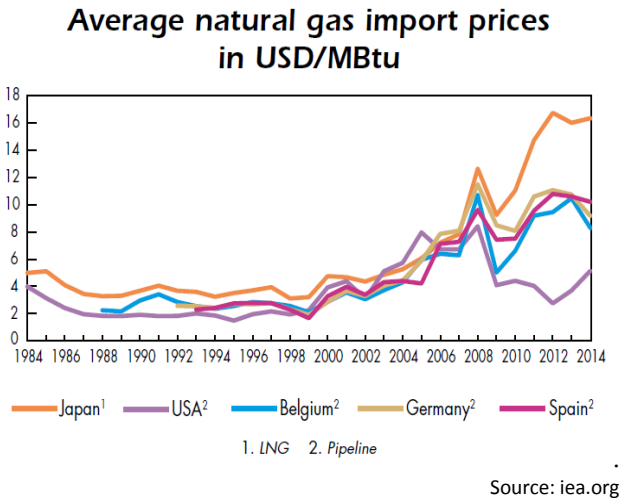
Table 1: Types of Coal Power Plants

Technology	Efficiency	Capital Cost (US$/kW)	Worldwide Availability
Subcritical	36%	1347	75%
Adv. Subcritical	40%<	N/A	
Supercritical	45%	1431	21%
Ultra-Supercritical	>45%	1529	4%

V. LNG AS A FUEL OPTION

In the aftermath of COP21 in Paris, in developing countries such as Sri Lanka, a discussion has arisen whether electricity generation should switch from coal to LNG in view of the threats posed to the existence of the human beings due to the adverse environmental impacts of climate change. This question need to be looked into from several different angles.

As a medium term alternative, Natural Gas has been preferred over coal due to relatively low emissions. Natural Gas comes in two forms due to ease of transportation. Compressed Natural Gas (CNG) is supplied over short pipelines for the countries who have domestic gas. But for island nations like Sri Lanka, there is no option but to go for Liquefied Natural Gas (LNG) in which case NG has to undergo two additional processes; Liquefaction and Regasification. Both these processes require additional investments and operational costs. Figure 6 shows NG supply prices to five countries since 1984. Supply curve for Japan is based on LNG while all other curves are for NG pipe line supplies. It can be seen that LNG supplies have been on the expensive side throughout and the gap has widened a lot since 2008.



Source: iea.org

Figure 8: Natural Gas Prices

Moreover, annual order quantity of LNG to Japan is around 100 million tons while that for Sri Lanka will be around 1 million tons initially. Therefore, it will be substantially high LNG prices for Sri Lanka and under moderate price increase scenario, the electricity unit cost difference between coal and LNG has estimated to be over 2 US Cents.

VI. ECONOMIC DEVELOPMENT

On the other hand, developed countries who went through the industrialisation early, have gained a big advantage in utilizing cheap power sources such as coal power and thereby have gained rapid economic development (Table 2). Developing countries who have been low carbon emitters throughout, are now saddled with the restrictions due to $2C^{o}$ issue and they are directed to go for expensive renewable energy which are plagued with issues due to intermittency and resource limitations in addition to being relatively more expensive.

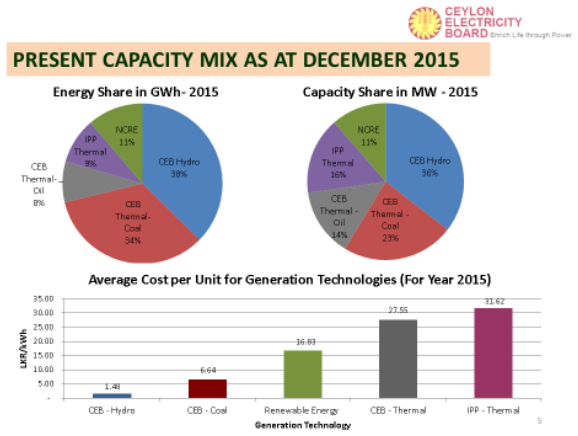
Country	Annual GHG Emission ($mtCO_2e$)	Annual GHG Emission (% World total)	Per capita Emissions ($mtCO_2e$)	Per Capita Per Capita GDP (US$)
World	-	-	4.9	9955
Sri Lanka	18.8	0.05	0.8	3926
India	1523.7	4.10	1.6	1581
Pakistan	160.5	0.43	0.9	1428
Myanmar	38.8	0.10	0.2	1203
Afghanistan	19.3	0.05	0.4	590
Indonesia	554.3	1.40	2.3	3346
China	7465.8	20.09	6.7	7924
EU	4488.4	12.08	8.9	31843
USA	6649.7	17.89	14.1	55835
Canada	726.1	1.95	14.1	43248
Russia	2799.4	7.53	12.6	9057
Norway	58.7	0.14	9.2	74734

Table 2 – Annual GHG Emissions and GDP Per Capita of Some Selected Countries (World bank data)

On the other hand, China has undergone a very rapid economic development in the last two decades and consequently have achieved a high per-capita GDP while sacrificing environmental damages as well as GHG emissions. However, in the resent years China has resorted to strict environmental control measures especially in regard to the local pollution, in view of the hardships people had to undergo due to haze and other impacts in their capital cities.

VII. ELECTRCITY GENERATION IN SRI LANKA

Sri Lanka has been a Renewable Energy dominated country throughout. More than 60% of its primary energy supply comes from biomass and Hydro power. In the Electricity sector too, the contribution from renewables is enviable and in year 2015 it was 49% (In 2015 world average was 23.7%)



Source: ceb.lk

Figure 9: Sri Lanka's Renewable Electricity Share and Cost per unit for Different Technologies

In the present Long term generation expansion plan 2015-2034 prepared by CEB, hydro, wind, coal, LNG, Non-Conventional Renewable Energy (NCRE) all are contained (Figure 10).

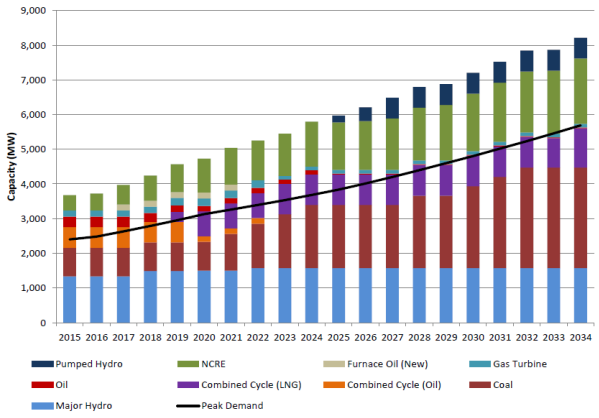


Figure 10: Proposed Capacity Mix 2015 - 2034

Local pollution by coal power plants cab be aggressively contained by having Electro Static Precipitators, bag filters etc. for capturing the fine particles and Flue Gas Desulphurisation techniques to address SOx issues. In Sri Lankan context, local pollution by transport sector is much higher than that from the power generation and effective management of pollutant control at coal power plants can make the effects less significant.

VII. CONCLUSION

From the above discussion, it is clear that although LNG is a cleaner fuel option, from a strategic point of view, it is unwise for Sri Lanka, already having over 40% of its electricity generation based on renewables, to go for LNG based power generation. The quantities of fuel involved, high cost of construction of a LNG terminal, its operational costs, security concerns if located near Colombo port, all outweighs the voluntary carbon reduction proposed by certain parties. The only outcome of implementing such a decision will be to continue the high tariffs of electricity, crippling any plans for rapid economic development in Sri Lanka.

Finally, it can be concluded that COP21 must focus on the countries who have emitted and polluted the atmosphere with carbon and already achieved a high level of economic development, to implement the targets shown in Figure 4 on a **Mandatory Basis** and poor nations to do it on a **Voluntary Basis**. At the same time every government must implement energy efficiency improvement measures in all sectors whereby carbon emission reductions can be more effectively achieved without sacrificing the economic development.

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