INVESTIGATE THE NECESSITY OF USE OF NUCLEAR POWER AS AN ENERGY SOURCE IN SRI LANKA WITH SPECIAL CONCERN ON PRESENT NUCLEAR TREND

BARS Bamunusinghe
General Sir John Kotelawala Defence University, Ratmalana, Colombo
ranga2300@gmail.com

Abstract - The escalation of electricity demand in a country has become an unavoidable factor. Technological development and raising people's living standards are the main reasons for increasing electricity demand. Electricity demand in Sri Lanka has grown at an annual rate of about 6% over the past ten years. Therefore, it is important to increase the total installed capacity through appropriate power generation combinations. Clean, reliable, affordable, balanced and sustainable energy structure by giving priority for renewable energy generation while minimizing the contribution of diesel and coal is the strategy of Government of Sri Lanka (GoSL). The unreliability of renewable energy sources such as solar, wind and hydropower questions their contribution to sustainable energy mix. Concerns about environmental issues have limited the development of fossil fuel power plants. Hence, Nuclear Power Plants (NPPs) can be considered as strong and competitive candidate in Sri Lankan energy industry. Ceylon Electricity Board (CEB) has included their proposal to consider nuclear power plant (NPP) in Sri Lanka after 2030. The higher plant factor, capacity, efficiency, reliability, zero or less emissions of greenhouse gases are the advantages of NPP while high capital and maintenance cost, complexity of technology, possible radiation threat are main disadvantages of NPPs. Political, social, environmental, cultural and economic bottlenecks are mainly connected with complexity of technology. There are many technologies being used for NPPs, but most of them are more complex, costly and accidents-prone. This research examines the necessity of nuclear energy to Sri Lanka with special concern on nuclear trends which are growing in Sri Lanka and all over the world.

Keywords - Nuclear Power, Energy mix, Nuclear trends

I. INTRODUCTION

The energy has played a prominent role in the human evolution throughout the history. Scarcity of electricity power has exaggerated by alarming inevitable power crisis over acquiring, sharing and utilizing energy. Availability, cleanliness, low cost and sustainability are the pillars where energy source exists. Sri Lanka has to pay more consideration to select a viable and sustainable power option as a main power source in the country. All most all the power sources are having advantages as well as disadvantages. In order to achieve the development targets in the country, it is paramount important to have electricity supply adequately with proper generation mix. The significant impact of electricity supply on economic growth of Sri Lanka is inevitable and attested (R Ferguson;W Wilkinson; R Hill, 2000)(R Morimoto, C Hope, 2001). Power saving could be a part of energy management for future Sri Lanka. However, there is a limitation to power saving where as 100 % saving through energy management is not practical. Developed countries such as USA, UK and Singapore are having considerably high per capita electrical consumption rate with more than 7000 kWh where as Sri Lanka is having approximately 600 kWh.

Two main factors to be considered while studying the viability of a source of energy are the '*behavior of the demand*' and other *'alternative options available.*' The requirement of connect additional power sources to

the supply is essential only if the demand in increasing significantly. Over the past 15 years, the demand has increased by 5% annually while in year 2016 and 2017 it has increased by more than 10%. Hence, the demand increment can be considered as a confirmed fact.

Except few options available with mini hydro power plants, hydro power capacity cannot be increased further in the country. There is no possibility of generating electricity power from tidal waves and wind power in large scale. Solar power has become an emerging source of power in the country today. In collaboration with Sri Lanka Sustainable Energy Authority (SLSEA), Ceylon Electricity Board (CEB), Lanka Electricity Company (Pvt) Ltd. (LECO) Government of Sri Lanka (GoSL) introduced the "Suryabala Sangramaya" (Battle for Solar Energy) to motivate people for implement Solar Panels power systems. This project has expected to add 200 MW to the national grid by 2020 and 1000 MW by 2025(Surya Bala Sangramaya, 2017). Even though it is a renewable energy source, the high flickers generate in the system, non availability at night and less reliability has created many uncertainties to depend upon solar power systems. Hence, renewable energy sources are having restrictions to recognize as main power source for a country. The main aim of establishing of SEASL by enacting the Sustainable Energy Authority Act No.35 of 2007 of the parliament of the Democratic Socialist Republic of Sri Lanka is to pave the way for Sri Lanka to gain energy security by protecting natural, human and economic wealth. Embracing the best sustainability practices by generating energy indigenously and use them efficiently are the objectives of the inception of SEASL.

The world today does not promoting fossil fuelled power plants considering their effect on the environment. Being a member country who ratified to "The Convention of the Parties to the United Nations Framework in Climate Change held in 2015" (COP21), Sri Lanka is having obligation to commit to decrease the greenhouse gas emission and take necessary measurements to hold the global temperature well below 2 degrees centigrade, from pre-industrial level. Considering the alternative power source, nuclear power can be considered as a clean and sustainable energy source.

There are several factors to be considered while introducing nuclear power as an energy source to Sri Lanka. Technological, Political, Social and cultural, financial and environmental factors are more important to assess vigilantly prior to introduce nuclear technology as a candidate to Sri Lankan energy mix. The use of nuclear power as an energy source has not been discussed adequately in Sri Lanka's power sector as well as the general public.

Besides the financial constraints that could be a potential barrier, the deterrence over using of nuclear energy is the main barrier to table this topic for further discussion. Without examining the pros and cons of use of nuclear energy in depth, it is unjust to comment on acquiring nuclear energy to fulfill the energy requirement of Sri Lanka. Many different technologies are involved with nuclear technologies. Considering above all, this study has been conducted to examine the necessity of using nuclear power as an energy source in Sri Lanka considering its viability with special concern favorable nuclear trends in the world.

II. METHODOLOGY

The research was a qualitative research. Hence, formulation of hypothesis before hand and testing it was not done. This chapter was dedicated to describe the way this research carried out to derive recommendation and comment on core argument, main and other objectives. The construction of research, sampling methodology, data collection method, data analyzing method are to be discussed in this chapter. The purpose of the methodology was to investigate the quality of the relationship of nuclear energy in Sri Lankan context. Hence, statistical data and numbers were seldom involved. The study limitations such as in-sufficient knowledge were restricted the smooth conduct of the research. Ethical considerations of the research also have discussed.

Before developing the core argument, the history of the nuclear industry with related to energy production sector was studies in depth. This was helpful to have an idea on the development of the sector and rise and falls of the nuclear industry and reasons for such incidents. There were very less and limited studies were found with related to Sri Lanka on nuclear energy sector.

The topic nuclear energy has not been a popular topic among the scholars and academia in Sri Lanka. The laboratory facilities and other infrastructures also were very limited. Sri Lanka Atomic Energy Board (SLAEB) was the main responsible body for promote nuclear related

experiments and educations. The main concern of SLAEB has focused on other usages of atomic energy rather than nuclear energy.

On completion of comprehensive study on history, previous researches as well as technology related to nuclear energy, the core arguments and other objectives were derived. This could be considered as the basement of the research.

The study on history was immensely helped to conduct case study on previous accidents and their consequences. Other than accidents, Following factors were studied during research;

- Technological factors
- Economical factors
- Social and cultural factors
- Political factors
- Environmental and Security factors

III. DISCUSSION

A. Energy Sector In Sri Lanka

The average power consumption in Sri Lanka is 35 to 40 GWh in an ordinary day. Concerning the consumption pattern in Sri Lanka, electricity tariff has implemented by CEB. The total installed generation capacity mix in Sri Lanka is approximately 4000 MW by August 2017 and it has estimated to be increased up to 6400 MW by 2025(Ministry of Power and Renewable Energy, 2018) with the rate of 6 % per year during year 2000 to 2015. As a result of motivate public to use of unconventional renewable energy, the percentage of Non-Conventional Renewable Energies (NCR)has increased from 4.1 % in 2007 to 10% in 2016 and is estimated to be 20 % by 2020(Ministry of Power and Renewable Energy, 2018).

The electricity generation has been increased approximately 4% while maximum peak demand has increased approximately 3% per year during this period. (LTGEP, 2016) The annual electricity generation in year 2015 and 2016 are 13,151 GWh and 14,301 GWh respectively. Accordingly, the average growth has increased up to 5.9 % and 8.7% during 2015 and 2016. The system peak demand also has increased in year 2015 and 2016 with 2210.4 MW and 2406.4 MW respectively with 2.5% and 8.9% (PUCSL, 2016). The total installed generation capacity of Sri Lanka by the end of year 2016 was 3,887 WM. There were 239 grid connected power plants owned and operated by government (27) as well as Independent Power Producers (207). The percentages of each producer category in year 2016 in Sri Lanka are as follows.

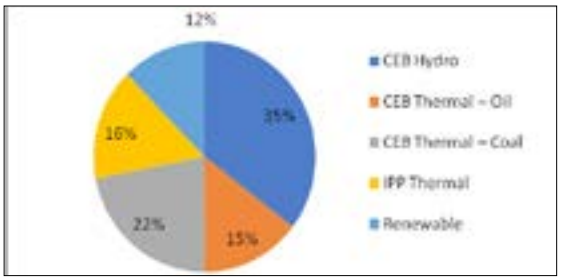

Figure 1. Generation Capacity Mix in WM in Year 2016
Source: Generation Performance Report, 2016
(PUCSL, 2016)

Despite of the higher installed capacity of CEB owned and operated hydro power plant, the power production and contribution of them to the national grid is depend on the rainfalls to the area where reservoir are located. This dependability of largest power producer has threatened the reliability of the power hydro power source and sustainability of the power system in Sri Lanka. The contribution of coal power has been gradually increased from 2015 to 2017 after commissioning of all three coal power plants at Norechcholei in 2014. Total capacity of 1259.3 GWh is available with main three hydro power reservoirs (Mahaweli, Samanalawewa and Laxapana complexes) in Sri Lanka. Since, the total annual power demand in Sri Lanka is approximately 14,000 GWh, the available reservoir capacity is only 08 % of annual requirement. (PUCSL 2016) Hence, the non-availability of rain for catchment area may significantly effect to the stability of the electricity supply of the country. Hence, a sustainable, reliable source to take over the base load of the country is essential for Sri Lanka.

Discussions are in progress to Commercialize Natural Gas discovery in Mannar basin with the initiative of Cairn Lanka Pvt Ltd being the only identified indigenous fossil energy source. GoSL expected to introduce a natural gas power plant to Mannar basin with 1000 kW capacity(Reuters, 2017). However, their quantities and industrial utilization capability have not been verified. Hence, it is of paramount importance to find alternative sources which easily can be replaced with fossil fuels.

B. Nuclear Energy and its Development

The history of nuclear science goes back to the 18th century and in its early stage it was focused on science of atomic radiation. Uranium was discovered in 1789 by German chemist Martin Klaproth and named after the planet Uranus. The atomic energy and nuclear fission was developed in 1895 to 1945.Nuclear reactions are two types. In fission reaction, large nucleus breaks down into two or smaller nuclei losing mass in the process. Two small nuclei react to form a bigger nucleus while releasing a large amount of energy as per Einstein's equation (E = mC2where E for energy, m stands for Mass and C is velocity of speed which is high as 3 x 108 ms-1) in fusion reaction.

As per the two summary reports published by MAUD committee of UK in 1941, the use of Uranium in a weapon and as a source of power using controlled fission reaction was highlighted and no sooner the attention was made harnessing this energy in a controlled manner for energy production (Power Generation) as well as naval propulsion systems. First atomic device test was carried out by USA on 16th July 1945 at Alamagordo in New Mexico with a Plutonium pile. Then USA dropped a U-235 atomic bomb on Hiroshima on the06thJuly 1945 and a Pu-239 device on the 09th August 1945 on Nagasaki. American based "Argonne National Laboratory" in Idaho designed first ever nuclear power plant to produce electricity in December 1951. "Atoms for peace" program was deployed by president Eisenhower in 1953 boosting the interest over researches on nuclear science with relevant to electricity production. This is today considered as the birth of nuclear power (World Nuclear Association, 2018).

C. Different NPP Technologies And Their Availability

At present several technologies used for nuclear power generations have been phased out while adding some new technologies. In Pressurized light water moderated and cooled reactor (PWR) the reactor core heats water, this is not boiled. This hot water then exchanges heat with a lower pressure water system, which turns to steam and drives the turbine. There are 232 reactors available in world (WNA, 2018). In Boiling Light-Water-Cooled and Moderated Reactor (BWR– 75 Nos) the reactor core heats water, which turns to steam and then drives a steam turbine. A pressurized heavy water reactor (PHWR– 49 No.s) is a nuclear power reactor, commonly using un-enriched natural uranium as its fuel that uses heavy water (deuterium oxide D2O) as its coolant and moderator.

Another important technologies use in nuclear reactors is Light water cooled graphite moderated reactor (RBMK), Gas-Cooled Reactor (GCR) and Fast Breeder Reactors (FBR). Advanced Boiling Light-Water-Cooled and Moderated Reactor (ABWR), Advanced gas-cooled reactor (AGR) and Water Cooled Water Moderated (WWER are not commonly used in the world. Focus Fusion reactor which burn deuterium, an isotope of Hydrogen which naturally occurred and can be easily obtained from water is one such alternative. It does not produce radioactive waste and reactors cannot meltdown. It increases the conversion efficiency due to high temperature and having lesser designing and constructing time for a plant. Study on the viability of this developing technology will help Sri Lanka to achieve her nuclear goal in future.

Nuclear plant produces electricity by converting water into steam which rotates a steam turbine coupled to a generator. Uranium fuels are consisting in Solid Ceramic Pellets. These pellets are packaged into long, vertical bundles. The fission or fusion reaction dissipates a huge amount of heat. Before use them in a reactor the ore has to undergone several processes. These are namely, mining and milling, conversion, enrichments and fabrication. All these steps involve with high technology and safety.

D. Comparison of Nuclear Energy with other Energy Sources

- Higher Capacity Factor - Capacity Factor of power plant is important aspect of for base load plant. This indicated the performance of the plant as well as efficiency of the plant. The net **capacity factor** of a **power plant** is the ratio of its actual output over a period of time, to its potential output if it were possible for it to operate at full nameplate **capacity** indefinitely. Further, it is important tool with respect to energy management aspect.

In a year, solar PV plant with 01 kW capacity will generate 2000 kWh while coal or nuclear power plant can produce approximately 7000 kWh/year. This is comparatively very high and having huge margin. The costs of battery pack which can be used for solar power system to store the power also high. Practically it will be difficult to store the solar energy and use them when sunlight is not available.

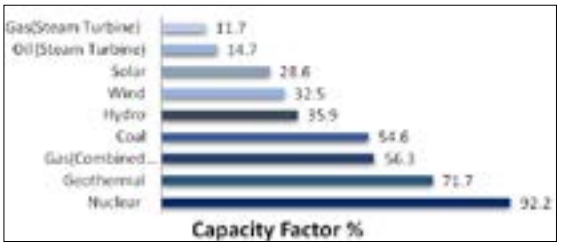

Figure 2. Capacity factors of Power Sources in USA- 2015 Source: US Energy Information Administration (EIA) and Nuclear Energy Institute

- *High Reliability* - Being an Island nation situated in Indian Ocean and very close to the Bay of Bengal the weather conditions are ever changing and unpredictable in Sri Lanka. Hence, the yield of Solar and Wind power also cannot be predicted or assured.
- *Higher Energy Efficiency* - Considering the fuel cost for generation a unit, the cost incurred for other forms of fuel and their quantities are very high. On based on average conversion rates available with Energy Information Administration, the fuel equivalent for electricity generated by 1000 MW reactor at 90 % capacity in one year which sufficient to provide 7.9 billion kWh are as follows (NEI, 2017).

Table 1. Fuel Equivalent for Electricity Generated by 1000 kWh NPP

	Fuel Type	Qty Required to provide 7.9 billion kWh	Unit yield
1	Oil	13.7 million barrel	1 barrel yield 576 kWh
2	Coal	3.4 million tons	1 ton yields 2,297 kWh
3	Natural Gas	65.8 billion cubic feet	100 cubic feet yields 12 kWh

Source: Nuclear Energy Institution, 2017

E. Why Sri Lanka Need Nuclear Power

Considering the disadvantages of fossil fuels and renewable sources, the necessity on NPP for Sri Lanka can be emphasized by examine the necessity of sustainable, reliable power source considering the requirement of Energy Diversity in a country. It is essential to have different type of energy sources for a country to depend the customers from price volatility. Price hike of crude oil was experienced by all over the world during year 2010 where the price of crude oil barrel increased more than $150 per barrel (EIA, USA 2016). The price volatility is common phenomenon for all the fuels. Proper and healthy energy diversity is required to nullify the affect or harm that can be happen to a country due to the rapid or sudden variation of any type of energy source. WNA emphasized the requirement of this mix finding optimal balance between need for human development and the protection of the natural environment. They target for 1000 GWe of new nuclear capacity to be added by 2050 by increasing nuclear power up to 25% of global electricity (WNPR, 2016) from the present share of 10% from world energy production.

A. At present Norechcholai has become the main power producer for the country. It was experienced sudden breakdowns more than 30 occasions as of May 2018 due to various reasons. Once it shutdown, it takes nearly two days to make the plant operational. Due to poor energy mix and limited standby energy sources in the country, power cut was mandate during this period.

F. Co-relation of Economy with Per Capita Electricity Consumption –

As per the research done by R Morimoto and C Hope in 2001 on the impact of electricity supply on economic growth of Sri Lanka, they have calculated that extra economic output of Rs. 88,000.00 to Rs. 137,000.00 for every 1 MWh increase in electricity supply in Sri Lanka in year 2001. Strong correlation between electricity use and economic development has been emphasized by many scholars(R Ferguson et al, 2000). The heavy drought experienced by Sri Lanka in 1996 coused to experienced severe power crisis and economic downfall. Same was experienced in year 2000 and 2001 with frequent power interruptions coused to reduce per capita electricity consumption from 296 kWh in 2000 to 292 kWh in year 2001. The GDP of Sri Lanka also decresed in 2001 up to 15.75 Billion US Dollars from 16.33 Bill$ which was in 2000.

G. Nuclear Trends in the World

As of 27th May 2018, 30 countries are operating 450 reactors with 393,836 MWe total net installed capacities.

Further, 59 new nuclear plants are under construction in 15 countries with two nuclear power reactors are in long term shut down. (IAEA, 2018). The total world electricity load share of nuclear power is 11 percent by 2014 (Nuclear Energy Institute, 2017). By 2016, France is the highest electricity load sharer in the world with 72.3 percent total electricity production of their country are fulfilling by nuclear power. Slovakia, Ukraine, Belgium and Hungary are obtaining more than 50 percent of their electricity using nuclear energy. At present 99 reactors with 34 BWRs and 65 PWRs are operating in USA. Another four plants (Summer 2 and 3 at South Carolina, Vogtle 3 & 4 at Georgia) are under construction. USA President Donald Trump placed nuclear first on America's energy agenda. Their main theme was the Global Energy Dominance of USA based on nuclear energy (NEI, 2017). US ***"Nuclear Energy Dominancy"*** may not restrict within the boundaries of the country. It has spread towards the abroad as well as.

H. Favorability on Nuclear Energy

NEI of USA is conducting 33 years long public opinion tracking program on public favorability to nuclear (NEI, 2017) and found that, the trend has gone up in favor of nuclear energy in long term from 1983 to October 2016 and stable in short term since 2010. According to the survey done by NEI they have found the followings;

- 84% nuclear should be important in future
- 82% agree that, US should take advantage of all low carbon energy sources including nuclear, hydro, and other renewable energy
- 95% agreed it's important to maintain diverse electricity sources. (NEI, 2017)

More importantly above research has found that the plant neighbors are more favorable to nuclear energy than general public. With compare to 27 % which strongly favor to have nuclear energy among the general public, 50% of people who are neighboring to nuclear plant are favor of nuclear energy.

I. Favorable initiatives in Sri Lanka

By establishing SLAEB and revising Atomic Energy Act in 2011 GoSL has shown their interest to develop nuclear technology in Sri Lanka. A pre-feasibility study has started in year 2009 (WNN, 2018) held up temporary due to the Fukushima accident in March 2011(Ranaweera, 2018). Sri Lankan government has included two 600 MWe NPPs by 2032 and 2035 to their Long Term Generation Expansion Plan 2015-2034. Since, the design and construction of nuclear plant takes approximately 10 to 15 years this can be considered as good initiatives.

Sri Lanka government has signed bi-lateral agreement with India in 2015 (WNN, 2015) and discussed with Russia in 2018 on sharing nuclear technology. Further the discussion in progress together with Japan, USA, and South Korea. The arrival of Deputy Director of Russian State Nuclear Cooperation Rosatom Mr. Nikolay Spassky in January 2018 signifies the interest of both countries to work jointly to realize the Sri Lankan dream of establishing NPP at least by 2031. (WNN, 2018).

The delegates from GoSL participated for the first time in the history to 9th session of AtomExpo International Forum in Moscow in June 2017. All giant in Nuclear Industry were participated to this forum and they express the aim of WNA to add 1000 GWe of new nuclear capacity by 2050 by catering 25% of world's electricity requirement. (WNN, 2017). The government has instructed all the higher educational institute to include subjects related to nuclear energy to the curriculum. Accordingly, necessary steps have been taken to amend the syllabuses of Advance Level and educate instructors, lecturers and school teachers on nuclear energy via student/ staff exchange programs with Japan, Korea, USA and UK (Ranaweera, 2018).

The sole authority of regulating the activities related to nuclear industry and radiological activities lies on Atomic Energy Authority in Sri Lanka. The DMC established Nuclear Disaster Early Warning System (NDEWS) in collaboration with AEASL, and has installed the online radiation Detectors of the system in the coastal belt of Sri Lanka from West to North facing to Tamil Nadu. These Detectors have been installed at Kalpitiya, Thalei Mannar, Delft, Kankasanthurai, Trincomalee, Colombo and Galle.

J. Nuclear Neighbors in Asia

The neighboring countries such as India (22 No.s), Pakistan (5), Vietnam (Planed 4, Research 1) and Bangladesh (01 plant to be commissioned in 2023) are equipped with nuclear energy technology. The World

Nuclear Association has recognized that Sri Lanka has expressed interest on consider, plan and start nuclear power plant. However, as a country, Sri Lanka has not forwarded country paper on her enthusiasm over nuclear power prospect (World Nuclear Association, 2018). At present India's power generation capacity is approximately 330,260 MW and peak demand is 159,541 MW. It indicates that, India is having 75,000 – 100,000 MW of excessive power. Even with this power surplus, Indian Prime Minter has mentioned their intention to build up further two nuclear power plants at Kudankulam which is 276 km from Colombo. Even though Sri Lanka does not have nuclear plants within the country, the threat of nuclear industry related accidents are possible to whole country.

K. Causes Affected Negatively to Promote Nuclear Energy

The complexity of the technology and possible radiation threat are the main causes affected negatively to promote nuclear energy. The impact of nuclear bombs and nuclear accidents mainly at Fukushima in Japan has slow down the progress of implement nuclear development projects. As a result of this, Sri Lankan government had to abundant the preliminary feasibility study conduct on nuclear energy. Among the other reasons, use of Liquefied Natural Gas (LNG) as an alternative, Negative Cultural and Social factors, Security and environmental threats, negative attitudes of people, policy makers and market forces towards acquiring a new technology such as nuclear energy, site selection difficulties, Negative Environmental Factors, financial and technical barriers, negative Impact of Accidents to Nuclear Energy Sector in Sri Lanka mainly the Fukushima accident in Japan in 2011.

IV. CONCLUSION

The main concern of this report was drawn to the necessity of nuclear energy to Sri Lanka as an energy source and favorable conditions over nuclear technology. The ever rising energy demand in the country is evitable and energy saving methods without hindering the development process of the country will not be a viable solution for this crisis. The history has taught that, when power crisis arises in Sri Lanka, the development process also has been held up or downfallen. Per capita electrical consumption in Sri Lanka is low as 600 kWh and need to improve. It is important to maintain a sustainable and reliable generation mix in a country. Two main factors to be considered while studying the viability of a source of energy are the *'behavior of the demand'* and other *'alternative options available.'* The behavior of Sri Lankan energy sector has emphasized the necessity of sustainable base load taker to the system. All most all the power sources are having advantages as well as disadvantages. Among the other alternatives, nuclear energy is a competitive yet controversial option.

Higher capacity factor, higher plant efficiency, lower unit cost and limited greenhouse gas emission are the main advantages of nuclear energy. New trends in nuclear technology such as plant neighbor's favorability over nuclear plants, increment of plant capacity, increment of security measures, positive concern of investors such Microsoft owner Bill Gates on small scale plants and political backing of political leaders such as Donald Trump and Vladmir Putin are positively impact to promoting nuclear technology.

Technical barriers such as lack resource personnel and skilled engineers and technicians along with financial barriers have negatively impact on promoting and selecting nuclear energy. However, these barriers can be overcome with the assistance of International bodies and foreign investors. Myths and negative attitudes of peoples, lack of political willingness and commitments, and manage the opposition of general public over introducing of nuclear power will be the major issue in Sri Lankan context. How to handle the public opinion will play a key role in this process and educate the general public would be the only option for that. Since, the lead time is very high and requirement of NPP is essential as per the existing situation and future forecasting, Sri Lanka need to accelerate the process early as possible to realize the dream of an indispensable requirement of NPP by 2030.

V. ACKNOWLEDGEMENT

I would like to express my sincere thanks to Capt(L) JU Gunaseela for providing opportunity for me to work on this and motivating me. Special thanks should goes to Mr S Bogahawaththa who helped me on this study and support me all the way through this research and committed enormously and provided invaluable assistance to me by supervising and guiding. During this research, Mr. Merril Gunathilaka, Senior Professor Rohan Lucas, Dr. Prinath Dias, Dr. Thushara Rathnayaka and Mr. Malinda Ranaweera were assisted me in various ways by spending

their valuable time. Without their help this won't be a success. I would specially thanks for all of them for their contribution. Further I would like to appreciate all my co-worker in the Department of Electrical, Electronic and Telecommunication for their assistance. I would like to be grateful to my beloved parents, wife Indika and two kids for being behind me right through the work and helping me in numerous ways. Finally, my thanks go to all who have supported me to complete the research work directly or indirectly.

VI. REFERENCES

CEB. (2016). *Long Term Generation Expantion Plan 2015-2034.* Colombo : Ceylon Electricity Borad .

Priyadarshana, B.(2011), *Nuclear Power plant for Sri Lanka by year 2020,*University of Moratuwa, 2011

PUCSL. (2016). *Generation Performance in Sri Lanka.* Colombo: Public Utilities Commission Sri Lanka.

Ranaweera, M. (2018, May). Nuclear Energy as a Viable power option. (B. Bamunusinghe, Interviewer)

Samarasinghe, D(2016), *Sri Lanka eyes Nuclear power,* Sunday leader, January 20, 2016,

Sri Lanka Atomic Energy Board(2015), *Indo Sri Lanka Civil Nuclear agreement,* February 23,2015

Wickramamsinghe, R (2016), *"Sri Lanka to build LNG plants in Kerawalapitiya:* Power Ministry.

WNI. (2014). Capacity optimization working group. *Optimized Capacity: Global Trends and Issues* (2014 edition), 4.

WNN. (2018, January 19). *Nuclear Policies* . Retrieved March 22, 2018, from World Nuclear News : http://www.world-nuclear-news.org/NP-Russia-and-Sri-Lanka-plan-nuclear-energy-cooperation-19011801.html

WNPR. (2016). *World Nuclear Performance Report 2016.* World Nuclear Association.