Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 160 (2019) 513–518

Energy Procedia

www.elsevier.com/locate/procedia

2nd International Conference on Energy and Power, ICEP2018, 13–15 December 2018, Sydney, Australia

Nuclear power as foundation of a clean energy future: A review

Sirazam Sadekin[a], Sayma Zaman[a], Mahjabin Mahfuz[a], Rashid Sarkar[b,*]

[a]*Military Institute of Science and Technology, Dhaka 1216, Bangladesh*
[b]*Bangladesh University of Engineering and Technology, Dhaka 1000, Bangladesh*

Abstract

To deal with climate change, clean energy is a necessity in the present world. Energy requirement is growing faster each decade. Over the long term some of the traditional sources (coal, gas and oil) have become inadequate to meet up the increasing demand. The current consumption rate of fossil fuel will make them extinct by the year 2050 to 2100. Based on these facts nuclear power plant is a strategic choice to develop a clean energy. This paper is an outcome of the review - Nuclear power as foundation of a clean energy future. Though nuclear energy can't be called as 'Carbon neutral' but it gives rise to much less emission of carbon dioxide than fossil fuels. Comparing with other energy structures, nuclear electricity chain emits a limited amount of greenhouse gas. Despite the uncertainty of building nuclear power plants in the future, this paper will further discuss climate changing issues have larger impact than the policies which are against the nuclear electricity production. The safety issue which is a public concern is also discussed here in short.

Keywords: Climate change; Carbon emission; Nuclear electricity; Nuclear reactor; Low carbon economy.

1. Introduction

Global climate change is a burning question for the whole world and the main reason behind this is the emission of carbon dioxide. To viably diminish CO_2 outflows whereas keep financial development, different nations have started to seek for modern improved ways among which clean energy development has ended up a broadly supported one.

* Corresponding author. Tel.: +88015523502581 ;
E-mail address: rashid@me.buet.ac.bd, prisly.sadekin@gmail.com

10.1016/j.egypro.2019.02.200

According to Japan's report "Building a clean energy society", a clean energy society is required to follow three principles, namely minimizing all the sector's emission, pursuing a simple lifestyle with higher quality and getting well along with the nature [1].

Clean energy city means a city where the low carbonization of all the different aspects have been realized. Clean energy cannot move forward without development in the energy field [2]. For this preferred clean energy solution, nuclear energy can be a breakthrough way which must be introduced more to the world. After hydrothermal powered electricity, Nuclear power is the second largest source of clean electricity. It is conceivable to generate a high amount of electrical energy in one single plant. Coal-fired power plants have a wide run of undesirable chemicals into the air - sulfur dioxide, nitrogen oxides, mercury, particulate matter and other toxins. Besides, fossil fuels are gradually exhausting, hence it might lead to an approaching worldwide scarcity of energy.

Table 1. CO_2 emission to produce 1KWh of electricity for various technologies [3].

Technology	g CO_2 per KWh
Renewable sources (solar power, water power, wind power)	10 - 40
Nuclear Power Plant	90 - 140
Combined heat and power in private houses	220 - 250
Gas burning plants	330 - 360
New coal burning plants	1000 - 1100

All of these advantages indicate that, nuclear energy production will continue to grow and offer a low carbon, clean energy.

2. Current status of world nuclear power

The world is marching forward to explore the full potential of nuclear power. This has taken the form of a revolution as countries like Russia, China, France, UK, USA has set successful examples of producing electricity by nuclear reactors. The nuclear capacity growth will be around 25 % in difference of only 25 years (2015 to 2040) [4].

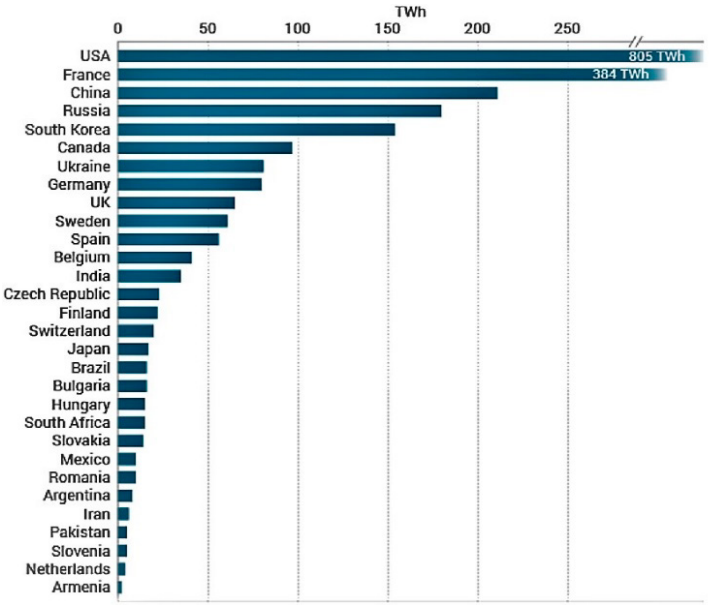

Fig. 1. Nuclear generation by countries in 2013 [5]

The first country that should be talked about when it comes to nuclear is Russia. Russia is the world leader in fast neutron reactor technology. The method that is most used in Russia is VVER (Water Water Energetic Reactor). France is a country which has set example that a country can sustain their demand by nuclear electricity. Almost 75% of their production come from nuclear field. Though the new government has proposed to decrease the number of reactors which has raised quite an eyebrows. Another reason the world is switching to nuclear power is OECD, the Organization for Economic Co-operation and Development. It consists 34 countries and try to improve social and most importantly economic policies [6]. One of their missions is to develop clean energy.

3. Greenhouse gas emission in nuclear power plants compared to conventional power plants

Greenhouse gas emission is a critical factor that needs to be considered while establishing a power plant. This factor varies drastically along with the power generating technology and source used in the power. Greenhouse gas is any vaporous compound within the air that's able of retaining infrared radiation, subsequently trapping heat within the air. By expanding the warmth within the environment, these are responsible for the impact, which leads to global warming. The longevity in the air and the amount produced from various fields makes carbon dioxide the main concern.

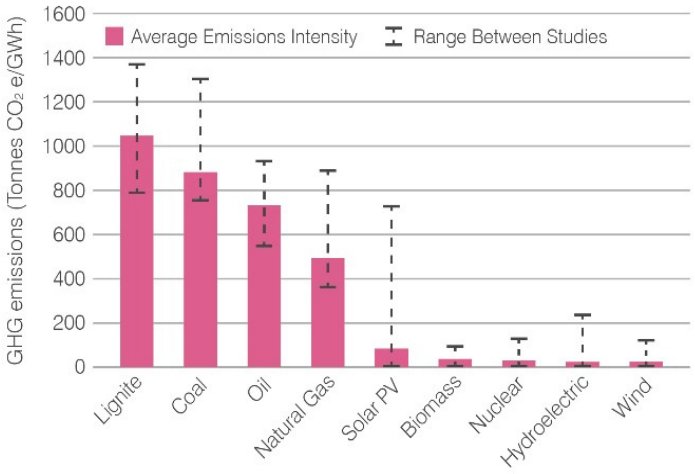

Fig. 2. Greenhouse gas emission from various plants [7]

The World Nuclear Association did research over 20 times to prove the efficiency of nuclear plant over conventional plants. From that review it was well established that nuclear plants are far better options for low greenhouse gas emission than fossil fuel plants. So it is clearly visible that nuclear plant is more eco-friendly than fuel based plants along with hydro and renewable source plants. Nuclear produced electricity is the path to choose to preserve the integrity of the environment and avoid global warming.

4. Current electricity generation

Electricity is a primary need in the modern world. The current development of society depends on the production of electricity. The conventional fossil fuel, reusable sources, nuclear, hydro etc. are the ways to produce electricity. Fossil fuel remains the most dominant as coal is most used as source, 38.1% in 2017. Natural gas remains second as it is used 23.2%. Hydroelectricity is another source for production of electricity (15.9%). But nuclear is still lagging behind them because their share declined by 3.4% and they have now only 10% [8]. The OECD countries are trying to give importance to cleanly generated electricity. As a result, in OECD countries 18% of the total electricity is coming from the nuclear field [9]. Also, fossil fuels are being used to their maximum potential, as a result, many countries have taken initiatives to shift to nuclear electricity. It is not for only fulfilling the growing demand, but also to ensure a safe environment.

5. Safe technology

'Safety' is the main concern of public regarding nuclear power plants. But nuclear power is safe compared to fossil fuels, which, according to the IEA, played a major part in the 6.5 million premature deaths attributable to air pollution in 2012 (both household and outdoor) [10].

People are afraid of nuclear energy sources because they emit radiation particles which can harm human's DNA and damage cells. But nuclear power plant doesn't emit that much radiation in the atmosphere because the reactor is shielded in a very moderate way. After the Fukushima nuclear accident in Japan in 2011, the major nuclear power countries were in a dilemma. With 440 reactors worldwide, only one – Chernobyl has been classified as a "major accident" by the International Atomic Energy Agency (IAEA). One of the main functions of the IAEA (International Atomic Energy Agency) is to act as an auditor of world nuclear safety. Each nation which works nuclear power plants contain an atomic security inspectorate and all of these work closely with the IAEA. The IAEA Security Benchmarks, created with participation by member States, serve as a worldwide reference for ensuring individuals and the environment and contribute to a high level of security around the world. Some Safety mechanisms of a Nuclear Power Plant are control of radioactivity, maintenance of core cooling, safe transportation of spent fuel and management of radioactive waste. Dealing with nuclear waste is also a concern for safety issues. All of the used nuclear fuel generated in every nuclear plant in the past 50 years would fill a football field to a depth of less than 10 yards, and 96 % of this "waste" can be recycled [11]. Practically, it is impossible to make a 100% safe power plant as there will be always a probability of accidents. Yet the nuclear power generation process is the safest and most secure technology for producing electricity in the present world.

7. Newcomer countries

30 countries are considering, planning or starting nuclear power programs, and a further 20 or so countries have expressed an interest [12]. At present, 30 countries of the world are operating 449 Nuclear Power Reactors and 12 countries, among them are providing 11% of the world's electricity by nuclear power. For a safe, secure and sustainable nuclear power programs, newcomer countries are following the regulations and safety guard. The emerging nuclear energy countries are now following the developed designs of the UK, USA, France, Russia and China as these countries have the reactor design license.

Table 2. Classification of countries according to different stages of planning for Nuclear Power.

Different stages of planning for NPP	Names of the countries
Power reactors under construction	UAE, Belarus, Bangladesh
Contracts signed, legal and regulatory infrastructure well developed or developing	Turkey, Lithuania, Vietnam (but deferred)
Committed plans, legal and regulatory infrastructure developing	Jordan, Poland, Egypt.

8. Innovative nuclear reactors

Innovative reactors are improved economy of scale if we compare to large reactors and smaller in size. These small reactors possessed great economic value which needs less initial cost of building a plant. Few small modular reactors are currently being proceed all over the world [13]. SMRs are usually considered to have an electrical output of 300 MW or less.

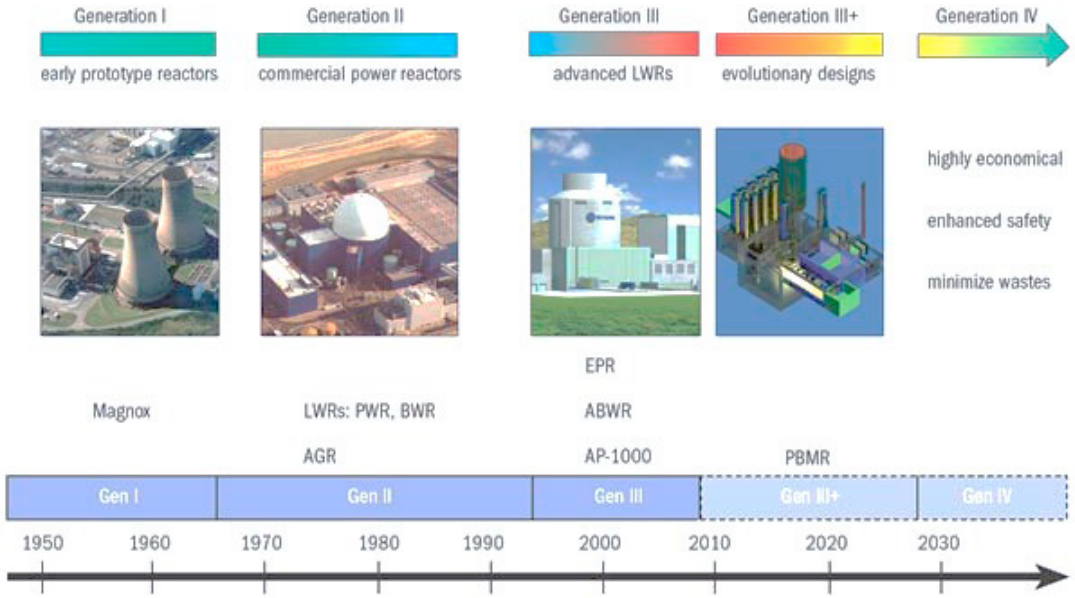

Fig. 3. Future reactor technologies [14]

Several generations of nuclear reactors are distinguished. Generation I reactors were developed during 1950 - 60s. Gen II reactors are mainly the commercial reactors. Gen III (and III+) is the advance reactors [15]. Also Gen. IV reactors are in progress under international collaborations aiming more sustainability. Higher safety functions are additional features of it. Six systems have chosen by experts for further R & D. They are Gas cooled fast reactor, Very high temperature reactor, Lead cooled fast reactors, Molten salt reactor, Superficial water reactor, Sodium cooled fast reactor [16].

Conclusive remarks

The demand for power is increasing rapidly with the expansion of civilization. On the other hand the environment is suffering from the conventional power plants which are emitting greenhouse gases and causing global warming. To solve all these problems, development of clean energy has become a priority to the world.

- Generally speaking, among all the clean energy options, nuclear power is one of the most beneficial ones. Not only this will solve the problem of the environment, but also this will meet up with the increasing demand.
- Operational nuclear power plants bring remarkable environmental benefits when it comes reducing acidification, ARDPs as well eutrophication. This system maintains the natural habitat integrity.
- Nuclear power encompasses a minimum level of toxicity and allows for large reductions in particulate matter formation. Radiation comes out from nuclear fuel cycle has less magnitude than natural radiation to ionizing radiation (Terrestrial/Cosmic radiation).
- If compared to counterparts, Nuclear energy production still remains less sensitive to climate change policy or geopolitical risk. The main concerns regarding nuclear power that were safety and control has been solved by developing science. Because of this increasing demand and to mitigate environmental damage nuclear power plant is being integrated into the power system.

Acknowledgments

The authors are thankful to MIST and Bangladesh Atomic Energy Commission for providing support.

References

[1] Ministry of the Environment, Japan. Building a Low Carbon Society. 2007
[2]Hu Yuana,b*, Peng Zhoua,b, Dequn Zhoua,b What is Low-Carbon Development? A Conceptual Analysis https://core.ac.uk/download/pdf/82011972.pdf
[3] Time for change https://timeforchange.org/co2emission-nuclear-power-stations-electricity
[4] http://www.world-nuclear.org/informationlibrary/current-and-future-generation/plans-for-newreactorsworldwide.aspx
[5]https://www.google.com/search?client=opera&hs=c3C&biw=1350&bih=635&tbm=isch&sa=1&ei=dbzlW-i1G8z8vgTO_rioDA&q=Nuclear+generation+by+countries+in+2013&oq=Nuclear+generation+by+countries+in+2013&gs_l=img.3...1837402.1841390.0.1845664.61.12.0.0.0.0.335.1240.2-4j1.5.0....0...1c.1.64.img..59.0.0.0...0.Obn3oXF_tMs#imgrc=lpvi_Nl4g1svRM:
[6] https://www.oecdwatch.org/oecd-guidelines/oecd
[7] https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=13&cad=rja&uact=8&ved=2ahUKEwjW_5qH8cfeAhVELY8KHf86CmsQFjAMegQIABAC&url=https%3A%2F%2Fwww.enerclub.es%2Ffile%2FOl0-vS_piwO5f1Ez5MwRMA%3Bjsessionid%3D5924FB5EDD827FE763C1BB3AE9340010&usg=AOvVaw1Q1DaUlgYScj8M39kmUvSy
[8] https://www.bp.com/en/global/corporate/energyeconomics/statistical-review-of-worldenergy/electricity.html
[9] http://www.world-nuclear.org/informationlibrary/current-and-future-generation/world-energyneeds-and-nuclearpower.aspx
[10] IEA, Energy and Air Pollution, World Energy Outlook Special Report, 2016. Attributed to WHO, World Health Statistics, 2016
[11] Krane, K.S., 1988. Introductory Nuclear Physics. John Wiley and Sons
[12] http://www.world-nuclear.org/informationlibrary/country-profiles/others/emerging-nuclearenergycountries.aspx
[13] https://www.ncbi.nlm.nih.gov/pubmed/18049233
[14] https://www.google.com/search?client=opera&hs=cVY&biw=1350&bih=635&tbm=isch&sa=1&ei=QMjlW6jvHZOgvQSY4qyoCQ&q=.++Future+reactor+technologies+&oq=.++Future+reactor+technologies+&gs_l=img.3...1388.5754.0.6913.21.8.0.0.0.0.260.480.2-2.2.0....0...1c.1j2.64.img..19.1.258.0..0j35i39k1j0i24k1.0.g5-Gz-8TgrM#imgdii=DIUpBmG_ZlwjYM:&imgrc=TpIFc5SEzOkSjM:
[15] http://www.world-nuclear.org/informationlibrary/nuclear-fuel-cycle/nuclear-powerreactors/advanced-nuclearpower-reactors.aspx
[16] https://link.springer.com/chapter/10.1007/978-14614-5716-9_6