Brief overview of the development of nuclear power

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Nuclear power is the technology involving the nuclear fission reactions. The science of nuclear reaction was started in the late 19th century. However, the nuclear power technology was only reliable since 1942. Until present, the nuclear technology has undergone three technological generations and the generation IV is expected to be available in 2040. Nuclear energy contributes to about 11% of total world electricity production. In this short report we briefly look over the development and contribution of the nuclear power technology.

Key words: *Nuclear power*

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1. INTRODUCTION

As early as 1896 the science of atomic radiation and nuclear reaction was started by Henri Becquerel, Pierre Curie and Marie Curie. A large fissile nuclide such as U-235 or Pu-239 absorbs a neutron and undergoes a fission reactor to split into two lighter daughter nuclei and release energy. A nuclear reactor is a system to initiate and control a nuclear chain reaction and make use of the released energy. The age of nuclear power has only been initiated since 1942 when Fermi and his group succeeded with the first nuclear reactor, Chicago Pile-1 at the University of Chicago [1]. The main technological evolution of reliable nuclear power was started in 1956. Up to present, there are about 440 commercial nuclear power reactors operable in 30 countries. The total electricity production from nuclear energy is about 11% of the world's total electricity production [2].

Nuclear technology is being applied in various fields of life, science and technologies. In this short report we present briefly the development and contribution of nuclear power to the electricity production over the world. Following this series reports on nuclear energy, discussion on why nuclear energy is chosen as an alternative resource and the advantage of it compared to other resources will be mentioned in the future reports.

2. DEVELOPMENT OF NUCLEAR TECHNOLOGY

The first commercial nuclear power stations started operation in the 1950s. After about 60 years of deployment the nuclear technology has gone through a long continuous evolutionary technological development with different design concepts and features. Figure 1 displays the evolution of the nuclear power technology. The evolutionary designs of nuclear reactors are categorized by several generations, known as Generation I, II, III, III+, and IV according to Gen-IV International Forum (GIF) [3]. Figure 2 displays the development of global nuclear energy capacity.

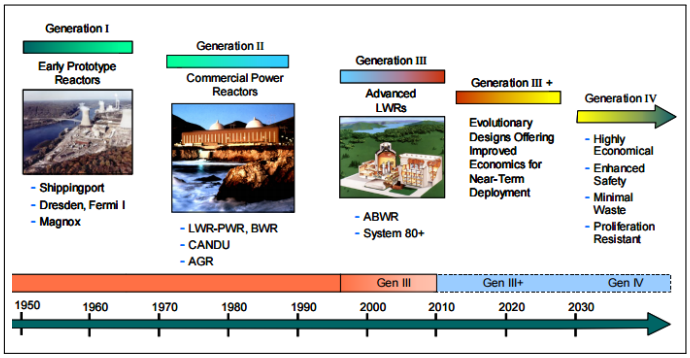

Fig. 1. Evolution of the nuclear technology. [3]

Generation I reactors such as Shippingport, Magnox, Fermi 1, and Dresden are the early prototypes of power reactors which were built and operated in 1950s. Generation II reactors are commercial power reactors in large scale, including boiling water reactors (BWR), pressurized water reactors (PWR), and Canada Deuterium Uranium Reactors (CANDU). Their construction and operation began in late 1960s and most of current Generation II reactors were built before 1990s as shown in Fig. 1. Originally a reactor was designed for a life-time of about 30-40 years. However, many of them are then extended to 50-60 years and even 80 years for economical purpose. Currently, most of operating reactors are Generation II reactors. For example, in the US about 3/4 of operating reactors are Generation II reactors.

During the lifetime of the generation II reactor, research and technology have significant achievement so that many improvements have been made and incorporated. As a result, Generation III reactor is a development of Generation II nuclear reactor with significant improvements in design. The improvements include fuel technology, thermal efficiency, passive safety systems and maintenance cost efficiency. The first Generation III reactor was ABWR at Kashiwazaki in Japan which began operation in 1996.

While recent new built reactors are Generation III reactors. A Generation III+ reactor offers advanced system design to ensure the safety of the reactor operation. They are more fuel efficient and are inherently safer with advanced passive safety system. Of course the construction cost is higher.

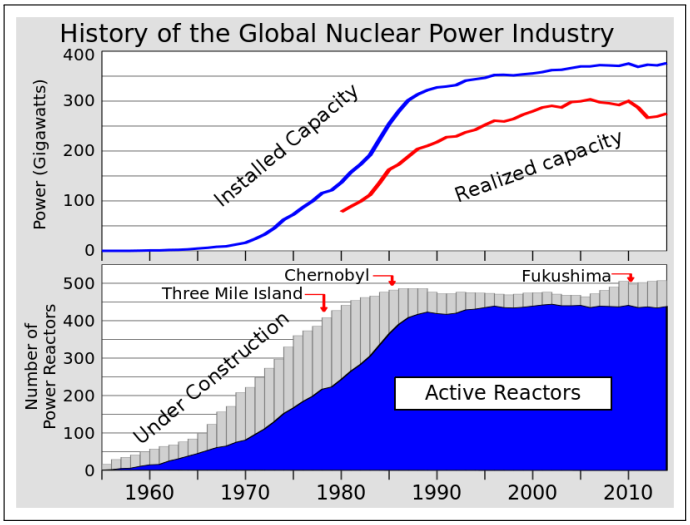

Fig. 2. History of nuclear development. [4]

In 2000, the Generation IV International Forum (GIF), collecting experts of 13 countries where nuclear energy is significant, was initiated to formulate the requirements for a fourth generation of nuclear systems. Six nuclear reactor technologies have been selected for further research and development as the Gen-IV reactors. Goals for Gen-IV nuclear systems are as follows:

- Meet the world's future energy demand
- Reduce CO_2 emissions
- Safety and Reliability
- Make efficient use of uranium natural resources
- Minimize waste production
- Proliferation Resistance.

3. CONTRIBUTION OF NUCLEAR ENERGY

Figure 3 displays the contribution of different energy resources to the world electricity production in 2012 [5]. The energy demand is increasing greatly every year. The electricity demand is increasing even much faster. While new renewable energy sources such as solar and wind are costly to supply in a large scale, nuclear energy is one of the proven technology which could supply energy in large scale with low CO_2 emission at competitive cost.

At present, among 30 countries where nuclear energy is being deployed, 16 of them have the share of the nuclear power of at least 25% of the total electricity. France has the biggest share of around 80% of its power from nuclear energy. Some other European countries such as Belgium, Czech Republic, Finland, Hungary, Slovakia, Sweden, Switzerland, Slovenia and Ukraine have about 30% or more. South Korea get more than 30% of their power from nuclear energy. In the US, UK, Spain, Romania and Russia it is almost 20% from nuclear. Before the Fukushima accident in 2011, Japan relied on nuclear power for more than 25% of its electricity [4].

According to the International Atomic Energy Agency (IAEA), seven new countries is expecting to launch their nuclear programs in the near future. Among these countries Vietnam is being planned to introduce two first nuclear power plants in next decade. The two nuclear power stations will be constructed in Ninh Thuan Province. The first one uses Russian technology and the second one uses

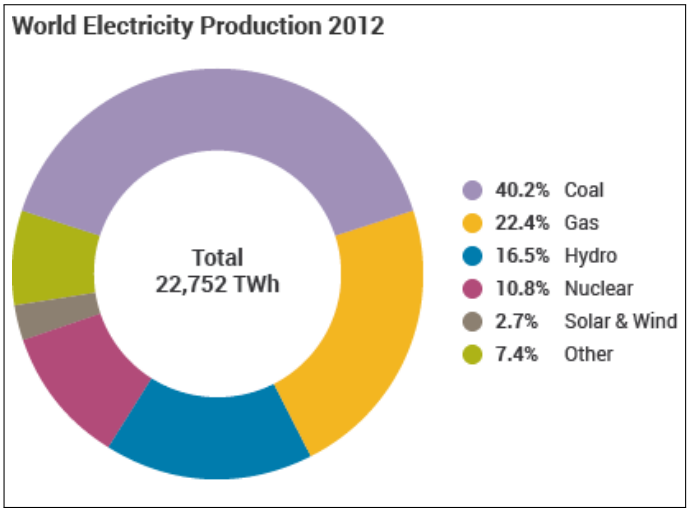

Fig. 3. World electricity production in 2012. Nuclear energy contributes to about 11%. [5]

Japanese technology. Since nuclear technology is very new in Vietnam, many factors need to be considered, among them safety is the most important to be considered for the introduction of nuclear power plants in Vietnam.

REFERENCES

1. The History of Nuclear Energy, U.S. Department of Energy, Office of Nuclear Energy, Science and Technology Washington, D.C. 20585.
2. http://www.world-nuclear.org/information-library/current-and-future-generation/nuclear-power-in-the-world-today.aspx
3. U.S. DOE Nuclear Energy Research Advisory Committee and the Generation IV International Forum, A Technology Roadmap for Generation IV Nuclear Energy Systems, (2002)
4. https://en.wikipedia.org/wiki/Nuclear_power
5. Electricity information 2014

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