Planning of Nuclear Power Systems to Save the Planet

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Planning of Nuclear Power Systems

To Save the Planet

Ekoenergo Oy

The nuclear power could generate 27 % of electricity by 2050 and 34 % by 2075. Nuclear electricity generation can make the biggest change in reducing greenhouse gas emissions and it would be possible to limit the global temperature increase to 2 degrees Celsius by the year 2100.

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Cover page: the Planet and Atoms. Created by my son Architect Teo-Tuomas Vuorinen

PREFACE

Nuclear power was proven to be an economical source of electricity in my previous book, "Planning of optimal Power Systems". However, the planned use of nuclear power was limited to 25% of electricity generation in 2050 because the uranium resources estimated to be limited. For this book the uranium resources have been re-evaluated and use of nuclear power could peak in 2075 by generating 34% of electricity of the world. Thereafter the nuclear share would drop to 25% by 2100, by which the renewable sources would generate majority of electricity.

Nuclear power is needed as an intermediate source of energy to solve the greenhouse gas problem. According to energy models done by the author of this book, the temperature rise can be limited to about 2 ^{o}C by 2100. To achieve this target all possible CO_2-free energy technologies should be exploited: both nuclear and renewable energy sources.

There are many industrial countries that can generate most of electricity by using nuclear power. One of them is Finland, which is becoming one of the largest producers of nuclear power per capita. Finland has four reactors in operation, one reactor under construction and another two reactors have received a license from the parliament in 2010. Thus in about 2020 there will be seven operating reactors in a country with five million people.

It has been a pleasure of being one of the engineers, who were designing the first Finnish nuclear plants with many fine colleagues in the Atomic Power Project Group between the years 1970-80. Since then we have made designs of Loviisa-3 plant, which concept of which was actually constructed in Tianwan in China. The Tianwan concept was the first design to use the core catcher in reality, because it was a requirement of the Finnish safety standards. The second core catcher will be built in the Olkiluoto-3 nuclear plant in Finland.

The Finnish experience of building several nuclear plants according to the latest safety standards could be used also in other countries. I will try to present my vision of a nuclear future from the point of view of an old chief design engineer. In my opinion there is still much to be changed in order for the new plants to be more economical and safe. Current light water technology can still be used, but the manufacturing of the plants should be done using more prefabricated modules in their construction.

August 2011

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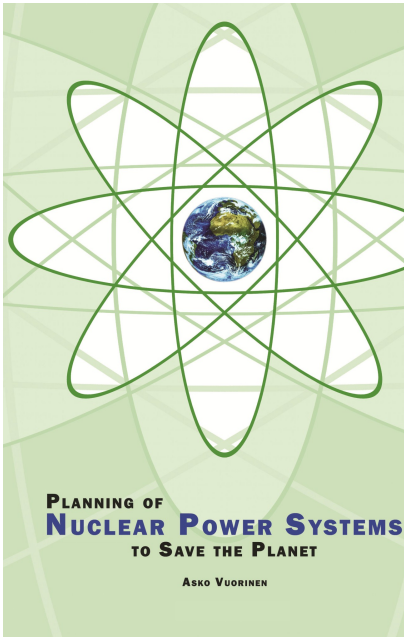
PLANNING OF NUCLEAR POWER SYSTEMS TO SAVE THE PLANET



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Nuclear power is still needed as an intermediate source of electricity because renewable energy sources cannot reduce the carbon dioxide emissions on their own. If the nuclear share of electricity generation will reach 26% by 2050 and 34% by 2075, the global temperature rise can be limited to 2 degrees Celsius before 2100 according to the forecasts presented in this book.

The second expansion phase of nuclear power has started and Finland has been the first western country to order a nuclear power plant in 2003. The Olkiluoto-3 plant will be the prototype of EPR plants, which will be also built in France and China. There are several options for nuclear power plants available and the most of them are reviewed in this book. Also new small and modular plants will be available in the near future.

The Chernobyl and Fukushima accidents were caused by the problems in the backup electricity supply systems. The safety of the existing plants should be improved by installing extra backup diesel generators. Additionally core catchers and aircraft protection systems will be needed in new nuclear plants. These improvements could decrease the probability of any major radioactive release to less than 10% by the year 2100.

Author: Asko Vuorinen

The author, Asko Vuorinen is from Finland which has had good and bad experiences from the competition since 1996. Finland has the highest electricity consumption per capita in the EU area and it has the highest CHP capacity per capita in the world.

It has four nuclear reactors in operation, one reactor in Olkiluoto in construction and two reactors in planning stage. The nuclear generation per capita in 2015 will be the highest in the world (7500 kWh/capita) after 2015 the Olkiluoto 3 plant will be in operation.

CV

Education

- High School: Keski-Suomen Yhteiskoulu, Student examination 1965

- Technical University of Helsinki, Electrical Department, Control Systems and Automation, Master of Science 1971

- Technical University of Helsinki, Mechanical Engineering Department, Power Plants and energy Economics, Licentiate 1994

Work experience

- Imatran Voima Oy, Nuclear Power Project, Design Engineer of the process computer system of Loviisa Nuclear Plant 1971-80

- Imatran Voima Oy, Power Plant Dep., Chief Design Engineer of investment and feasibility studies for new power plants, 1981-91

- Wärtsilä Oy, Modigen Oy, Managing Director, Development of gas and oil fired power plants, trading of electricity and planning of power systems in several countries including Finland, USA, India, Russia, Estonia and Latvia 1992-2010

- Ekoenergo Oy, Energy consulting and energy systems planning, teaching energy systems and publishing books and internet pages 2010-

Part time jobs:

- Ekoenergo Oy, Family Company, Managing director, energy saving and consultation services 1979-2010

- Espoon Jalkapalloilun Tuki Oy, Managing director, construction of football hall and maintaining building and property services, 1989-2005

- Espoo Stars Oy, Football Club, Managing director, financing of football club and establishing youth soccer services 2001-2005

- Teovision Oy, Family company, Managing director, construction and maintaining building and property services, 2006-

- Lappeenranta University of Technology, teacher in doctoral course of Power Systems, 2012-

Publication of following books:

1. Planning of Optimal Power Systems, the first edition 2007, 349 p. second edition 2008

2. Energiankäyttäjän käsikirja (Energy User's Handbook). 204 p., 2009

3. Planning of Nuclear Power Systems to Save the Planet, 304 p., 2011

4. Energiankäyttäjän käsikirja 2013, 241 pages, 2013

Fortum Oy (e.g. Imatran Voima Oy)

Originally a state owned utility company which is building power plants and transmission networks. Today the company is generating 53 TWh of electricity and 17 TWh of heat in Nordic Countries, 17 TWh of electricity and 25 TWh of heat in Russia and about 2 TWh of electricity and 7 TWh in other countries including Poland and Great Britain. The company has power capacity of about 10.000 MW and turnover of 6000 million euros annually.

Wärtsilä Oy

Wärtsilä is one of the oldest engineering companies in Finland, which was established in 1834. It is constructing, selling and maintaining diesel, gas and dual fuel engines for power plants. Today the sales of engines for power plants and marine applications are about 6000-8000 MW annually. The power plants sales in about 3000-4000 MW, which includes 2000 MW of gas and dual-fuel power plants and 1000 MW of oil fired plants. The turnover of Wärtsilä is about 5000 million euros annually.

Ekoenergo Oy

Ekoenergo Oy was established as a consulting company for energy services in 1979. It is one of the first companies which are thinking ecologically to save the world. It is publishing books and maintaining internet pages for education purposes. The books have been used as a text books in many universities and internal courses in large companies.

ACKNOWLEDGEMENTS

It has been a privilege for me to be one of the pioneers to design and execute the first nuclear power plant in Finland. I wish to mention from the old IVO days my good friends Kalervo

Nurmimäki, Markku Tiitinen and Tapani Kukkola, who have also read the manuscript of this book and have given valuable comments on nuclear plants and waste disposal.

I also wish to thank the former director general of STUK Dr. Antti Vuorinen, who has also read the manuscript and commented on radiation and safety aspects of nuclear power. He was the man who was actually behind the western safety standards, which Finland has adopted when building its nuclear plants in the 70's.

In addition I wish to thank my former colleague, Prof. Björn Wahlström from Technical Research Centre VTT and Ilkka Mikkola from TVO for their comments. Additionally my new colleagues Harry Lindroos, Jussi Heikkinen and Lars-Gustaf Martin from Wärtsilä have helped me in many ways in writing this book. Lars-Gustaf is the director of nuclear business at Wärtsilä and he has read the manuscript and given many valuable comments.

I would celebrate all of the old pioneers in nuclear power engineering. It will soon be 60 years since the first nuclear power, the Experimental Breeder Reactor (EBR-I) in the United States started electricity generation for the first time. Electricity production at the EBR-I started on December 20th, 1951, when project engineer Harold Lichtenberger turned a switch, which lit a 200 W lamp. The EBR-I was a breeder reactor, which has the potential to generate more fissionable materials than the reactor consumes.

The second great moment for all the Finnish engineers was the moment, when the first nuclear power plant in Finland was connected to the network. This happened on February 8th 1977, when the Loviisa-1 unit was connected into network. Now we are waiting, that the Olkiluoto-3 will make Finland the number one in nuclear electricity generation per capita.

Finally, I would thank all of my colleagues for the fact that Finland will be the first country to start the final disposal of spent fuel in 2020. This will happen in Olkiluoto site for the first time in any country in the world. By the year 2120 all of the spent fuel from the five existing reactors will be disposed into ground rock repository, 400-700 meters below sea water level.

Thus the energy which has come from the ground will be buried back into the ground, and practically no environmental effects on the nature will be left. I will hope that the future generations will be happy that our generation has taken care of the waste that has come from the nuclear power plants. All things considered I believe that we have done the best that could be done.