NUCLEAR ENERGY SIGNIFICANTLY REDUCES CARBON DIOXIDE EMISSIONS

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ABSTRACT

This article is devoted to nuclear energy, to its acceptability, compatibility and sustainability. Nuclear energy is nondispensable part of energy sources with vast innovation potential. The safety of nuclear energy, radioactive vaste deposition, and prevention of risk from misuse of nuclear material have to be very seriously abjudged and solved. Nuclear energy is one of the ways how to decrease the contamination of atmosphere with carbon dioxide and it solves partially also the problem of global increase of temperature and climate changes. Given are the main factors responsible for the renaissance of nuclear energy.

Key words: nuclear energy, carbon dioxide emissions, renewables, R&D in reactor technology, environmental impact of fossil fuel energy, renewables

INTRODUCTION

The nuclear industry in US produces about 20 % of electric energy and in 2001 it was the first time when the production of nuclear energy was cheaper than that from fossil fuel (coal). The power plant V1 in Jaslovske Bohunice is the second most cheapest source in our country, producing energy for half of the average expences of our all energy sources.

We can be sure that the nuclear energy will be the nondispensable part of energy sources also in future. Nuclear energy owns a vast innovation potential. Further research and development have to react sensitively to the needs of acceptability, compatibility and sustainability of nuclear energy. The safety of nuclear energy, radioactive waste deposition, and prevention of risk from nuclear materials misuse have to be very seriously abjudged and solved.

Nuclear energy is one of the ways how to decrease the contamination of atmosphere and it solves partially also the problem of global increase of temperature. Nuclear energy prevents of 1.8 billion ton of emissions. In Europe it represents 550 mil t of CO_2 emissions yearly. This is equivalent of emissions of 140 mil cars.

AIMS

The main aims of nuclear energy are:

- to continue to keep an important share in energy production in long term perspective,
- to innovate and improve technology and safety of nuclear industry,
- permanently improve its economic, environmental and mental compatibility and acceptability.

WORLD ENERGY SYSTEM – DOMINANCE OF FOSSIL FUELS

World Energy Trading Organizations (WETO) tried to suggest the description of the future world energy system (WETO [1]). According to their conclusions, world energy demand is projected to increase at about 1.8%/year in the next three decades. While industrialized countries experience a

slowdown in the growth of their energy demand 0.4 %/year in the EU, conversely, the energy demand of developing countries growths rapidly. The world energy system will continue to be dominated by fossil fuels almost 90% of total energy supply in 2030. Oil will remain the main source of energy (34%) followed by coal (28%). Natural gas will represent about 25 % of world energy supply. Coal demand could grow rapidly as it becomes more competitive than other fuels. The change in the fossil fuel shares impacts considerably on the carbon intensity of the world energy system and on the associated CO_2 emissions.

Due to the continued dominance of fossil fuels, world CO_2 emissions are expected to increase more rapidly than the energy consumption (2.1%/year on average), reaching in 2030 twice the level of 1990.

NUCLEAR POWER DOES NOT KEEP PACE WITH TOTAL ELECTRICITY PRODUCTION

Nuclear energy increases slightly in absolute terms. During the 1990-2000 decade the growth of nuclear was 2.7%/year, but this rate weakens to 0.9%/y over the projection period. In 2030, nuclear represents 5% of the world gross inland consumption (GIC) compared to 7% in 2000.

Globally, energy from renewable sources is expected to cover 8% of world energy requirements in 2030 essentially due to the continuous decline of traditional biomass consumption in the Third World.

The development of nuclear power does not keep pace with total electricity production: nuclear world market share comes down to 10 % of total electricity production in 2030, from 18 % in 2000.

World electricity production from renewables is expected to rise from 2 % in 2000 to 4 % in 2030, mainly because of a rapid increase in the electricity production from wind.
More clear is it from Table 1.

Table 1. Trends of shares in electricity production.

Electricity production	Share (%) in 2000	in 2030
nuclear	18	10
large hydropower	19	13
renewable	2	4

The other technologies for electricity generation, based on fossil fuels (gas, oil and coal) will cover the rest.

NEW NUCLEAR POWER PLANTS

Mainly the two type of nuclear power plant can be considered for close future (WETO [1]):

- Standard large Light Water Reactor (LWR) - is supposed to exhibit capital costs slightly increasing over time due to increased investment in security measures. In the technology case, the investments as well as O&M costs are assumed to be about 35 % lower as compared to 2030.
- New evolutionary nuclear design. This technology is assumed to be introduced gradually after 2010 and costs about 30 % less to construct than the LWR by to 2030 thanks primarily to its inherent safety characteristics. Probably it gains a substantial share of the total nuclear market (approx. 12 %). For the nuclear technology case this type of plant is assumed to be 35 % cheaper to construct and 35 % to operate.

Two kinds of blocs attract attention of nuclear community nowadays:

It is EPR, the improved and verified reactor PWR with many original elements of inherent safety, developed in cooperation of France and Germany (Framatom, EdF-CNEN, Siemens KWU) and pressurized reactor cooled and moderated with light water advancing CIS row of blocs, VVER-640/V407 with 1800 MWt and 640 MWe (contemporary 290 MWt).

The basic difference among these two groups of blocs is according to attitude to the largest reactor incident. While VVER640 concentrates to prevent by all means the melting of central reactor zone improving and suggesting new technologies of cooling, the EPR concept is based on the fact, that when some safety systems will fail and the central zone will be melted, the fused mixture will flow down to the protected position, where it will be partially under control.

In the frame of international research also some other projects will take place in the first half of this century (SLUGEŇ et al. [2]):

- Light water cooled systems – innovation for deeply burnt fuel, energetic fission of actinides, concept of supercritical reactor, etc.,
- Gas cooled systems – high-temperature thermal reactor, modular HTR, and two industrial prototypes of GT-MHR and PBMR prospective till 2010, fast neutron gas cooled reactor, etc.,
- Special cooling media – concept with melted salts, liquid metals, especialy Na, Pb and Pb-Bi-eutectics,
- Cogeneration – combination electric production – desalted water,
- Hydrogen production – hydrogen economics and hydrogen - petrochemical market.

NPP OPERATE VERY SATISFACTORY

Nuclear power plants (NPP) are developing permanently. They represent the most satisfactory part of energy and electric sources. World Association of Nuclear Operators (WANO) [3]) has pointed the progressive attributes improving their techno-economic characteristics:

- Unit Capability Factor has raised during the last 10 years from 77 % to 83 % representing equivalent of new 45 reactor blocs given into operation,
- Collective Radiation Exposure felt down during the last ten years approximately to 1.1 ManSievert/bloc,
- Coefficient of Industrial Safety Rate has decreased during the last ten years to one half of previous value.

About 25 % of reactor blocs are working for more than 25 years. The key moment for today´s nuclear energy is to receive the permission to operate for further period. Only this can prevent 10 % decrease in nucleus expected for 2010 in US. After deep complex control of blocs, Oldbury (Magnox) asked for 10 y prolongation of the permission to operation to 40 y, Calder Hall asked for 10 y to 50 y, Oconee, Hutch and others asked the same in US, Tokai (Kansai Electric) finaly asked for 30 y of prolongation to 60 y of operation, etc.

CARBON DIOXIDE EMISSIONS

The overall effect of nuclear technology case is a worldwide reduction of CO_2 emissions in 2030 of 2.8 % (4.6 % in the OECD). At global scale there is expected considerable increase in nuclear electricity generation. Overall nuclear contribution can increase from 9 % to over 15.5 % (from 16 % to 37 % in the OECD). Nuclear power can penetrate into the high to medium annual loads displacing coal and gas fired electricity production.

The amount of globaly and yearly produced CO_2 is approximately about 6 500 Mt, in Slovakia about 11 Mt. Additional 17.6 Gt of CO_2 would correspond to the production of. electric energy produced in NPP in years since 1980 to 2002 (cca 42 PWh) if it would be produced using natural gas.

The content of CO_2 in atmosphere today increases about 1 %/y. Since 1860 the highest mean Earth

temperatures are measured these years. And to fulfile obligations from Kyoto seems difficult. Japan, to reach the aim (-6 %) ought to construct 20 new 1300 MW/bloc till 2010. In EU (-8 %) the rate of decrease is slower than expected. US (-7 %) refuse to reduce emissions according to Kyoto at all, pointing that it could threaten their further economic development. CIS finaly ratified Kyoto Protocol in March 2005. This commitment push it closer to 50 % border needed for its overall validity.

NEED OF ENERGY FOR DEVELOPING COUNTRIES

Not negligible is also the need of energy for developing countries. New reactor blocs construction is shifted to Asia, where the increase of share of nuclear sources will reach aditional 8 % to total 26 %! China intends to construct 30 new nuclear power plants (about 36 GWe till 2020 y), South Korea plans new 10 blocs till 2015 and will increase with them todays production of 40 % (16 NPP of total 112 TWh/y), North Korea intends to built 2 blocs, Taiwan 4 new blocs, India 20 blocs till 2020 y and 5 NPP cooled with liquid Na, Pakistan till 2015 two blocs, Japan about 15 blocs till 2020 y (additionaly to 54 blocs in todays operation), and Iran 4 blocs in close future.

NEW TECHNOLOGIES

Also new technologies help to support nucleus. New generation of reactor blocs is projected. In US the National Environmental and Engineering Laboratory (INEEL), together with the Argonne National Laboratory create the Top Center of R&D in nuclear energy mainly in the field of advanced nuclear technologies, GENERATION IV and technology of advanced nuclear fuel cycle. Around 2030 they could start new era of advanced nuclear energy blocs with higher safety, reduced wastes and better economy. In US the Final Design Approval for advanced project AP 600 got Westinghouse and for boiling reactor ABWR it received GE (General Electric). In France, European Pressurized Reactor (EPR) is preferred. Its economic advantage can be seen at contracted construction of at least 6 – 7 blocs. One billion FF has been already invested into R&D.Two pressurized reactors are already working at Penly and Seine-Maritime , Fr.

According to the last trends the **attitude of broad European community** to nuclear energy changes. The majority votes for atomic power plants (e.g. in US 60 %, in South Korea 92 %, France 67 %, Germany 81 % etc.) Convention from Kyoto on reduction of CO_2 emissions supports the case.

More close **communication of operators with inhabitants** is accented to dissolve their negative expectations. The possibilities of effective bloc shut down and its final decommission, as well as the routes for high radioactive waste processing are emerged. It can be demonstrated by projects of decommission of NPP Tokai-1 (250 mil. USD, 15 y), NPP Zion-1, NPP Vandellos-1 (300 mil. USD, 30 y), etc.

Nuclear power activities can enhance also **liberalisation of energy market**. In US full liberalisation, in EU at least 25 % according to present law. Problems can be expected in case of reconstruction works in progress.

Important effects on nucleus may impose **energy producers** (SUCHOMEL[4]):

a) To increase load factor by:
   - The shortage of reactor general repairs
   - The decrease of nonplanned intervals
b) To increase the nominal output of reactor bloc
   - Loviisa (Fin) – already the increase about 100 MW (11 %)
   - Olkiluoto (Fin) – the increase 125 MW (pile 710 MW/bloc), 2 blocs
   - NPPs in Spain – 500 MW increase together in next ten years
c) Exclusion of nucleus from electricity corporations and unite them into great nuclear

conglomerates with more united operation and better support.

d) Internalisation of nuclear energy production of electric energy :
   - Comp. Amergen goes to buy NPS TMI + NPS Oyster Creek
   - Comp. British Energy goes to invest into Ontario Hydro
   - Comp. EdF invests to Hungary, Austria, Swiss nuclear energy markets
   - Take place also the broad fusion process: Siemens AG + BNFL (British Nuclear Fuel PLC), Magnox + BNFL, IVO + NESTE, Framatome + Cogema, Tractatel + Iberdrola, etc.

RENEWABLES

Could renewables really help? The main technologies affected by R&D probably improved in their techno-economic characteristics during the next decades could be:

- Biomass gasification for electricity production in small scale (less than 25 MW) combined cycle plants
- Photovoltaics
- Molten Salt Tower Solar plant with storage. This technology will be realised in decades after 2030 in developing countries where most of the physical potential exist,
- Small hydro, assumed to be a mature technology registering insignificant gains over the projection period,
- On-shore wind turbines (over 500 kW capacity), highly competitive, in spite of its intermittent character, with massive development worldwide but without significant impact to electric market.

The renewables result now in 3 % reduction in worldwide CO_2 emissions.
The technology cases defined here do not offer definitive solutions for the global CO_2 emission problem. This is largely because the power generation sector represents only a part of the energy market. The extension of these energy technology cases to other important CO_2 emitting sectors (road transport, the residential and tertiary sector) should be a priority in the future.

THE MAIN FACTORS OF RENAISSANCE OF NUCLEAR ENERGY

Lastly we try to identify the main factors responsible for the renaissance of nuclear energy:

- Prolongation of the operation period of NPP to 50 or 60 years
- Shortage of licencing procedure of new piles
- Increase of passive and active safety of NPP
- Increase of pressure on CO_2 production decrease
- Permanent increase of costs of fossil fuels
- Small development rate of technologies of renewables

In this connection should be underlined the increasing overall lack of energy.
This is evident for US, Great Brittain, Japanese, China, CIS, some states of EU etc.

Prezident George W. Bush visiting nuclear power plant in Calver Cliffs, Maryland, June 22, 2005 has said: „Times come to built new atomic power stations in our country. More and more people accept opinion, the more nuclear energy mean the more cleanliness and the more safety for our country. America didn´t construct new NPP since 70-ties. In spite of this, Franch has built 58 and China is constructing eight ones.“ The sum of 1.1 billion USD will support construction of new plants. The speaker of the Commission for Nuclear Energy Regulation, Eliot Brenner certified that in the case of 20 % yearly demand, will US need about 100 new piles in the next 20 years.

General director for energy policy Joan McNaughton has warn that the aims in decrease of carbon dioxide in atmosphere and to speed up the use of green energies will not be probably reached and it will

be unavoidable to bring as soon as possible decission on construction of new nuclear piles. The Association of British Nuclear Industry asks for 10 new NPP for fight against emissions. Ukraina intend to built 11 new nuclear piles till 2030 as has been announced by Ludmila Timošenkova on May 3, 2005.

Russia´s industry and energy minister Victor Krishenko said on Dec. 17, 2004, the nuclear share of electricity generation in Russia is planned to increase by up to 23 % by 2020. In European region of this country the share could be as high as 40 %. Mr. Putin said, that his country has become convinced once again that the nation´s nuclear power program has all the possibilities for further development . By 2010, two nuclear units would be commissioned and 10 existing units would receive extensions of their lifetime operating licences.

A report by the Japan Atomic Industrial Forum predicts that nuclear will account for about 60 % of the country total electricity generation by 2050 – nearly double the current percentage. From about 2020 electric fuel vehicles and fixed fuel cells are expected to be prevalent, greatly reducing the burden on the environment. Hydrogen fuel will supply 10% of consumed energy by 2050 and 70% of that hydrogen is expected to be produced through nuclear heat.

Yosako Fuji, the head of Japan´s Federation of Electric Power Companies , as well as Anne Lauvergeon, the head of France-based Areva group, support the view that nuclear should be included in future negotiations on the Kyoto protocol as an acceptable tool to help fight emissions.

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