# Future of the Nuclear Power Generation in Hungary

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**Abstract**. In the paper the development options of electric power generation industry in Hungary are considered. A stable element of the energy system is the Paks NPP. Value of Paks NPP is demonstrated. Preparatory works for new nuclear project are presented. The feasibility of construction of a new plant is shown. Basic aspects of preparatory work and its results are presented in the paper.

## 1. INTRODUCTION

Development perspective of the Hungarian economy and the same time its vulnerability is dependent on the energy import. More than 70% of total primary energy demand is covered by import. The share of import may reach the level of ~90% within ten years if the recent tendencies will continue to dominate. The share natural gas coming from one source is very high in the energy import. The disturbances in the gas supply became a regular event occurring practically every winter. In the Energy Policy approved in 2008 the Hungarian Parliament recognized the priorities of sustainable development and climate protection, while the security of supply and economical aspects have been also emphasised. The goals of Energy Policy might be achieved by increasing the share of renewable energy and low-emission technologies in the energy system, improving the efficiency of end-use and energy savings, diversification of energy sources, gas supply lines, also diversification of import markets.

The electric power generation industry of Hungary is diversified considering the technologies. The gas, nuclear and coal are the main sources at growing share of renewable technologies. However the system needs further development since big part of existing capacities is obsolete. The average age of plants is over twenty years, two third of the plants are older 20 years. After recent temporary drop of power consumption a moderate economical growth can be expected and predicted for long-term with annual increase of electric energy consumption between 0.5 to 1.5 percent.

The EU policy, national interests and the trends in the industry define development options for power generating industry in Hungary.

The European Council plan calls for a 20 percent binding target for reducing greenhouse gas (GHG) emissions (compared with 1990 levels), a goal of 20 percent share of renewables in the electricity mix, a 20 percent increase in energy efficiency by the year of 20201. With these targets the EU aspires to become the world's most energy effective region and the EU will retain its position as global leader in renewable energy. There is also a strong commitment of EU to reduce emissions by at least 35 percent by 2030 and by over 50 percent within 2050. At the centre of the new energy package stands the target to reduce CO2 emissions by 20 percent within 2020, compared with 1990-levels, without affecting workplaces or competitiveness.

Considering the differentiated targets for EU member states, Hungary seems to be able to increase the share of renewables up to 13% by 2020 compared with the 4.3% in 2005. Higher target will demand unbalanced social effort and cannot be achieved without essential loss of competitiveness of

[1] Official Journal of the European Union 5.6.2009, DIRECTIVE 2009/28/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC

Hungarian economy. The positive effect of the development of renewable power generating sector on the income sources and jobs creation seems to be very moderate under Hungarian conditions. Consequently for achieving the GHG emission reduction targets the energy mix has to be developed under strict control of the GHG emissions.

Behaviour of the power industry in recent situation is rather controversial. The industry is oriented to low risk incentives, preparing new project on import gas. Only one ongoing project exists in Hungary utilizing domestic lignite. It seems the industry neglects the adverse effects of increasing gas-dependence. Development of renewable capacities is strongly correlated by availability and amount of state subsidies provided in different forms for the investors and producers. An intensive development of renewable capacities is limited by their technical maturity, economical constrains and grid stability aspects, also by natural conditions in Hungary.

Summarizing the mentioned above facts and circumstances one can conclude that the energy mix in Hungary has to be developed in line with improving sustainability, secure supply and stable for long-term pricing which means that the investments into power generating capacities should focus on low-emission technologies and diverse import sources.

Assuming that the projects for increasing of energy saving and efficiency of end-use and the new renewable capacities will cover the net increase of demand in Hungary in next two decades, assuming further that the growth rate of the economy will be moderate, 3000-4000MW new power generation capacity will be needed between 2015-2025 for the replacement of shut-down old plants. In case of higher growth rate Hungary will need 6.000 – 6.500 MW new capacities by 2020-2025. While considering the options for development of power generating capacities, nuclear power should be taken into account, both the existing nuclear power plant at Paks as well as the construction of new plant.

## 2. VALUE OF NPP PAKS

The role of nuclear power generation in Hungary can be demonstrated on the example of the Nuclear Power Plant Paks, which can be summarised as follows:

NPP Paks is the cheapest and largest producer of electricity in Hungary, the share in domestic production was 37,2% (14818GWh) in 2008
Production cost-index was lower than the average price index during the whole history of plant operation
Safety level of the plant is as in case of Western PWRs of same vintage
The plant demonstrates high reliability/availability (86%)
The plant saves 5.6 million tons of CO2 per year, no environmental impact (27 years of operational experience) and the external costs are internalized
Social impact is important: qualified human capital, high-tech jobs, the plant is the largest regional employer
Stockpiling of fresh fuel for two years it is the most important capacity concerning security of supply,
Public acceptance of the plant operation is continuously high (~70%).

Summarizing the recent situation it is obvious that Paks Nuclear Power Plant is an unavoidable element of the Hungarian electricity system.

The Paks NPP strategy is to operate safe and as long as economically reasonable. Reactor power up-rate implemented recently provides 8% increase of plant output due to utilisation of modernised fuel assemblies and some minor modifications. The payback of power up-rate is less than four years. The licensed term of operation is 30 years, which expire between 2012 and 2017. 2000MW replacement capacity would be needed additionally, if the existing nuclear capacity would be shutdown when the originally licensed term will expire. An extension of operational lifetime is feasible due to robustness of design and good condition of the plant. Justification of safety of additionally twenty years of

operation is in progress. Solid regulatory system exists for the control and approval of licence renewal. Business assessment shows that the extension of operational lifetime is a reasonable decision. Other conditions as intermediate storage of spent fuel and final repository of radioactive waste are manageable. Extension of operational lifetime is widely supported by public.

The Hungarian Parliament approved on 21 November 2005, with 96.6% of votes the information on the extension of the operational lifetime of Paks Nuclear Power Plant. The resolution reads: "The Parliament takes note of the information on the extension of the operational life-time of Paks Nuclear Power Plant, as a solution necessary for the long-time and safe provision of the country with electric energy."

## 3. THE NUCLEAR OPTION FOR THE DEVELOPMENT OF POWER INDUSTRY – THE POLITICAL DECISION

Increasing the share of nuclear power generation in the energy mix of Hungary is an idea for compensation of volatility of energy import, which was affecting more or less the Hungarian energy policy during last three decades. The extension of capacity of Paks NPP has been practically continuously on the agenda. (The site at Paks was selected with the intent to built 6000 MWe total capacities.) In early eighties significant efforts were made for extension of capacity of Paks NPP by WWER-440/213 type units. In eighties several other offers were made concerning the construction of a new power plant, e.g. a French proposal for construction of several 1,000 MW units. During the second half of the eighties, preparations were made for the building of two WWER-1000 units. The site north from existing plant has been prepared for the new units and on-site transportation infrastructure has been built. Paks NPP founded a high school for education of future plant employees. Hungarian government cancelled the project in 1988. Later, in 1997 Paks Nuclear Power Plant Ltd made an attempt to take part on the MVM tender for new capacities. Feasibility study for constructing two ~600MW units has been made considering three technical and business options: a CANDU-6 reactor unit by AECL, an AP-600 unit by Westinghouse (which got its design certificate at that time) and the WWER-640 type of Russian Atomstroyexport which was under development that time. The time consuming preparation of nuclear options did not fit into timeframe of the tender therefore the nuclear proposals failed2.

In line with international tendencies and acknowledging the role of Paks NPP in the energy supply of the country and recognising the need of emission-free technologies, the Energy policy approved by the Hungarian Parliament in 2008 required preparation of the political or "in principle" decision of the Parliament regarding construction of new nuclear capacities.

The "in principle" decision of the Parliament is a mandatory step in preparation of nuclear projects in Hungary required by paragraph 7 (2) of the Law CXVI on Nuclear Energy (1996).

Hungarian Power Companies Ltd3 (MVM) and Paks NPP Ltd launched a project for preparation of the political decision of the Parliament. Considering the possibility of further development of nuclear power generating capacity in Hungary following main topics has been studied:

Long-term energy supply, demand-capacity forecast
Analysis of electrical grid
Economical issues and financing
Public acceptance, communication
Technical aspects of feasibility and environment issues
Regulatory framework and licensing

[2] As a matter of fact there weren't any tender winners announced in the category of over 200 MW.
[3] Hungarian Power Companies Ltd. (MVM) and companies controlled by it constitute Hungary's national power group: MVM Group. Paks Nuclear Power Plant Ltd. is part of the Group. The Group is one of the most important players of domestic electricity market in Hungary.

The works have been performed in six working-groups managed and staffed mainly by experts of Paks NPP. Engineering companies, research institutes, consultants in financing as well as consultants in public relation and communications have contributed also to the project. Preparatory works for the in-principle parliamentary decision on the new project required about 300 engineer-year efforts.

For backing the proposal for governmental and parliamentary decision following information sources have been used:

International Atomic Energy Agency documents regarding preparation of new projects
Energy-outlooks of International Energy Agency, OECD Nuclear Energy Agency and U.S. DoE Energy Information Administration
European Utility Requirement Document
Public information on preparatory works of new projects in different countries, e.g. U.S., Finland, Slovakia, Chez Republic, Romania, Bulgaria and UK.

Arguments of other interests groups within the power industry and also the opinion of non-governmental organisations, including anti-nuclear groups have been also studied.

Three main documents have been compiled on the basis of studies on the topics listed above: a preliminary feasibility study, an environmental impact study and a study on radwaste and spent fuel issues.

The need of further power generating capacity development has been justified in the Feasibility Study. The feasibility of construction of a new nuclear power plant has been demonstrated. Considerations have been made regarding unit capacity
with respect to the demand,
possibility of integration of the new plant into Hungarian grid system,
efforts needed for the integration into Hungarian grid in case of different site options.

Considering the forecast of energy demand and development perspectives of power generation industry in Hungarian, and also the targets of the energy policy, building of new nuclear capacity seems to be reasonable and feasible. Analyses show that a new nuclear power plant with capacity two times 1000 to1600 MWe might be integrated into Hungarian energy system between 2020 and 2030. However the system management is more difficult in case of larger unit capacity using the Hungarian system reserves only. Further regional technical and market integration may create better conditions for selection of larger capacity units. Also the load-follow capability of the plant is of large importance. Connection to the grid will require significantly less effort and grid development in case of Paks site compared to any other potential sites. (These potential sites are in North-East of Hungary.)

Selection of the Paks site has other advantages too:
This is already a nuclear site owned by Paks NPP Ltd.
There is a prepared construction area for the units.
Well-developed infrastructure and human resources are in place.
Communities in the region accept and support the new project.

There are several reactor types available at the market with capacity between 1000 and 1600 MWe and with acceptable technical and safety features (e.g. AP-1000, EPR, Russian 1000 MW WWER designs). Obviously the safety should not be a decisive element of design selection; all possible types of Generation III shall comply with national and international regulations and best international practice. The European Utility Requirement Document (see http://www.europeanutilityrequirements.org/) specifies the set of technical and safety requirements. Preference should be given to pressurized water type reactors, since the Hungarian operational experience and knowledge base could be best utilized in this case. However the possibilities for an in-depth analysis of technical options was limited; the Low on Nuclear Energy limits the extent of the

activities in pre-parliamentary phase of preparation, e.g. binding communications with potential investors and suppliers shall be avoided prior to the political decision of the Parliament.

Comparing to other options the new nuclear project requires the largest capital investment per unit capacity (EUR/kW) and more than ten years for preparation, licensing and construction, the production cost of nuclear power plant is competitive. The basic options for the financing have been studied and the applicability for Hungarian conditions of different financing concepts of running nuclear projects have been analysed. Final mechanism of financing will be developed in the coming phase of preparation of the project. The project should be implemented with maximum responsibility of suppliers, however a turnkey type implementation of the project is questionable. The involvement of Hungarian subcontractors has an important role.

Licensing of the new plant will be a great challenge for the authorities as well as for the industry. A well-developed legal system exists in Hungary for the licensing of a new nuclear power plant, which is based on the lows for environmental protection, low on use of water resources, low on nuclear energy and low on electrical energy. There is a distributed regulatory system in Hungary, i.e. different aspects like environmental, nuclear of licensing are in competence of different authorities. Some streamlining of the licensing procedure will be desirable especially in interactions between authorities. There are scientific and technical institutions for support both the regulators and the industry in licensing processes.

The preliminary environmental impact study has been performed using the conservative bounding parameter values for releases and effluents of the plant and the worst-case probabilities of anomalous events, enveloping the known parameters of the types considered and for the largest possible capacity.

The best argument for the acceptability of the new project has been gained from the environmental monitoring data collected during 25 years of operation of existing plant and the comprehensive environmental impact study performed for the environmental licensing of licence renewal. Although the site is located at the river Danube and the units 1-4 of Paks NPP are fresh water cooled, the new plant should be erected with cooling towers for elimination of the load on the aquatic biota and fresh water resources. The preliminary environmental impact study demonstrated the feasibility and acceptability of the new plant at Paks site. In the Energy Policy approved by the Hungarian Parliament in 2008 the obligation of the state have been underlined defining the necessary governmental actions for solution of disposal of radioactive wastes and spent fuel.

In a 30 March 2009 vote, the Hungarian parliament has given overwhelming preliminary support to a government proposal to begin the detailed preparation for the construction of new nuclear generating capacity at the Paks plant.

## 4. PREPARATION OF THE NEW PROJECT

After the in-principle approval of the Parliament the second phase of the project preparation has been started. A new MVM preparatory project launched July 2009. In this phase the main tasks are the following:

Development of the proposal for an ownership and financing structure, which provides the adequate financial resources for the project.

Mapping of feasible investment and procurement strategies, analyses of their effect on financing.
Comparative analyses of investment and procurement strategies
Comparative analyses of bidding strategies and possible project management models
The effect of strategic investors on investment-, procurement and bidding strategies
Typical payment conditions, required payment guarantees on vendors' market

Analyses of potential investors

Motivation of participation
Willingness to take risk, risk sensitivity
Preferences on share (majority / minority)
Preferences on technical issues (type of units, vendor, capacity, etc.)

Preparation of the bidding process, development of terms of reference, bid invitation, bid evaluation.

In-depth analysis of certain economical/business issues, e.g.
Long-term demand-capacity forecast, tendencies of the international market.
Analysis of the effects of parallel operation of old and new units on electricity market.
Vendors' market analysis (2010-2025).
Identification of possible bottlenecks at suppliers' market.

In-depth analysis of technical issues, e.g.
Development of the concept for cooling system of the plant
Regarding the national grid: analysis of the transmission capacities, grid system regulation, reserves and required grid development.

Preparation of the site and environmental licensing, also the licensing for use of water resources, preparation of the licensing process of the construction. For the preparation of the site and environmental licensing first of all the existing information has to be evaluated and the studies already performed have to be reviewed. The scope of further site investigations also the extent of environmental studies will be defined by the findings of the review.

Implementation of an effective communication programme targeting all layers of the society local, regional and countrywide, fostering the positive attitudes and building up the confidence of the people.

Development of the nuclear cluster around of new project dealing with social and economic relations of the new project.

## 5. CONCLUSIONS

Prolongation of operation of the existing nuclear power plant at Paks and construction of a new plant will improve the security of supply and produce essential share of electricity with practically zero emissions and negligible environmental effects.

The new nuclear capacity will really contribute to the sustainable development and decrease the vulnerability of economy due to import dependence. The new project stimulates the development of scientific, engineering and construction capacities in Hungary, creates thousands of jobs for more than ten years.

The experience of nuclear operators, knowledge of engineering and scientific support organisations, and the legal system exist for the preparation, construction and licensing of plant. The Paks site is well studied with necessary infrastructure and with possibility to use the synergies provided by the site. Hungarian people supports prolongation of operation of existing nuclear power plant and the extension of the nuclear capacity at Paks.