ИНСТИТУТ ЗА ИКОНОМИЧЕСКИ ИЗСЛЕДВАНИЯ НА БЪЛГАРСКАТА АКАДЕМИЯ НА НАУКИТЕ
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FINANCIAL ASPECTS OF NPP CONSTRUCTION: IMPLICATIONS FOR NPP BELENE

New technical safety requirements for the future NPP have been set after the Fukushima accident in 2011. This has led to costs increase and new models for NPP construction financing. Along with these models the article discusses technical problems associated with the building of a financial model to determine the financial viability of a project for a new NPP construction, and the decision to be made in defining its main parameters. The outcomes of the study have direct implications and applications that may be used in studies and decision for constructing NPP Belene.
Keywords: financing, financial models, nuclear power plant.
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1. Introduction

The nuclear energy is a leader in the electrical energy production in the EU among other fuel and types of energy production facilities. In 2016, the nuclear energy generates about 28% of the electricity in the EU. It is expected that this share will diminish by 2050 to 18% of the energy production at the account of the increase of renewable sources share (EC, 2016). Nuclear energy plays an important role in combating CO_2 emission reduction by ensuring half of the low-carbon production (EC, 2017).

Despite a reduction of nuclear energy share in the coming decades is expected, the future plans envisage investing only in the EU between 349 and 456 billion EUR in new nuclear plants with a capacity of 95 GW (EC, 2017). The largest NPP market is assumed to become Asia, China and India taking lead positions as they are in urgent need to replace their very polluting coal-fired thermal power plants.

The new investments in nuclear energy however have an alternative. After the 2011 Fukushima accident as a result of the new technical requirements for higher safety for future NPPs the costs for NPP construction and operation increase. The safety costs per

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nuclear reactor increase according to different estimates from 35 to 140 million EUR (EC, 2017). The lifetime extension costs per reactor grow between 5 and 25% after Fukushima, representing 63 EUR/kW on average (EC, 2017). These new requirements are the main reason for the rise of the levelised cost of electricity (LCOE) of the nuclear energy (Figure 1).

The NPP cost structure is dominated by the investments with a share from 60% to 85%, followed by the operating costs – with a share 10-25%, fuel – with a share of 7-15% and decommissioning costs – up to 1% (NucNet, 2014).

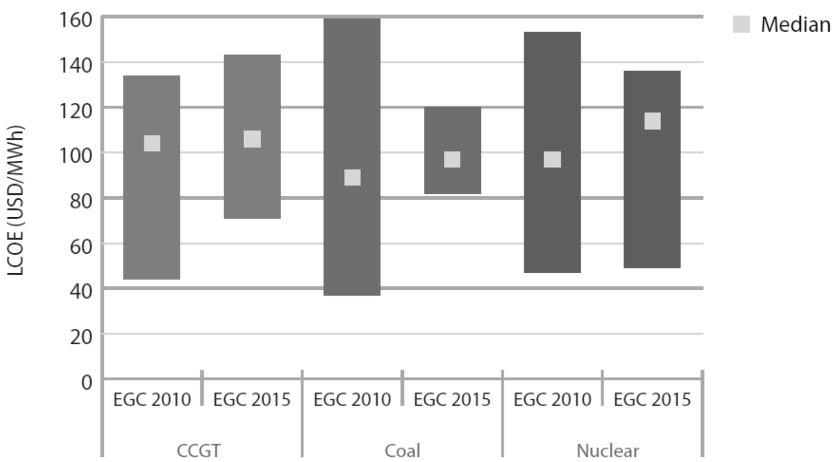
Besides the high investment costs, the nuclear energy entails a long period of construction and operation, complex technology, high regulatory and political risk.

These features of the nuclear energy go along with the imposed restrictions in the banking schemes after the 2008 crisis. Europe has introduced the Basel Accords II and III for the sector, while the USA – special regulations such as the Dodd-Franck Act, the Volcker rules. These rules are related to regulation of the capital adequacy of the banks, their liquidity and responses to stress market situations. This leads to increase of the requirements of the banks for financing large infrastructure projects, incl. for NPP construction.

The Fukushima and other accidents with NPP operation in the last years, the increased public pressure in some big countries and the and the traditionally negative attitude of the "green" to nuclear power have led to the withdrawal of international development banks from funding nuclear projects. All this over time creates a crisis in the financing of new NPPs, which on the other hand induces the development of new models of such financing.

Figure 1

Levelised cost of electricity (LCOE) in 2010 and 2015 for various technologies at 10% discounting rate



*CCGT refers to energy production through cogeneration.

Source: OECD-NEA & IEA, 2015.

The report focuses on these funding models and discusses recent developments and features related to the construction and use of financial models to calculate the viability of new NPP projects. The obtained outcomes of the study are interpreted in terms of their applicability making the decision to build the Belene NPP.

2. Models for NPP construction financing

The financing of NPP construction and operation projects is a complex economic and political task. The huge investment costs of nuclear projects require taking serious risks (D'haeseleer, 2013). For this reason, the allocation of risks is a primary task in clarifying the concept of financing nuclear projects.

Each project has an owner who either independently or through the assignment of a special project company starts to develop the project. An important part of the project idea development is the project financing structure and exploring the opportunities for attracting investors who are external for the owner as well as finding the external capital.

The literature and practice distinguish four “pure” NPP financing models. These are the models of financing through state funds, corporate financing, cooperative financing and project financing.

The initial and traditional model of NPP financing is through state funds, also called national model (Lucet, 2015). This model was widely used from 1960s to 1980s in France, USSR and USA, marked by a peak in NPP construction. This model is still used mainly in regulated markets, e.g. China (Qinshan 1 и 2), UAE (Barakah). Typical for this model is that the NPP ownership and operation is done by a state enterprise. The state funds are used for both direct financing of the project company capital and indirectly – for providing a state loan guarantee for the project company.

A mixed company with a capital of 4.7 billion USD is established for the NPP Barakah, as the capital is provided by the state corporation ENEC and the prime contractor – the South Korean company KEPCO (Table 1). The debt financing of 19.6 million USD comes from four sources: the UAE Ministry of Finance, four investment banks, the Korean and the American export crediting agencies. Thus, the necessary financing for the NPP construction to the amount of 24.4 billion USD has been secured.

Table 1

Sources of financing the construction of NPP Barakah

SOURCES OF FINANCING	Billion USD
Equity, incl.:	4.700
ENEC	3.904
KEPCO	0.976
Debt, incl.:	19.600
Ministry of Finance	16.900
National Bank of Abu Dhabi; First Gulf Bank; Bank Standard Chartered; HSBS	0.250
KEXIM	2.500
USEXIM	0.732
Project budget	24.400

Source: Compiled on the basis of IAEA data, 2018.

A version of this financing model is the intergovernmental loan for NPP construction. Usually such contracts contain clauses falling outside the nature of nuclear power plant construction. Such examples exist in China lending to Pakistan, the Russian Federation used that model to credit the construction of NPPs in Belarus, Bangladesh and India.

The corporate financing model uses the balance of the project company to attract funds. There two options as well – financing through participation in the project company or through providing credit. The project company bears the entire risk in this model.

Examples for using this model can be found in NPP constriction in China, Finland, France, India, Japan, South Korea, Russia and the USA. In case of state ownership of the NPP it is assumed that this model is close of the state financing model.

A version of this model is the provision of financing by the Engineering, Procurement and Construction (EPC) Contractor, mainly used for NPP construction. In that case the contractor ensures the financing usually through credits from investment banks, export credit agencies, and in some cases directly from the state. It is also possible to ensure financing through debt emissions (most often corporate bonds), or participation in the capital of the contractor. There is a large participation of the state when the contractor is a state-owned company. Then, this model is also close to the model of state financing. This model is applied for nuclear projects in the Russian Federation, China and France, which give credits to their own companies implementing nuclear project. In Japan this model is used by emitting bonds on the capital market. Similar tools are used in China by the China National Nuclear Corporation (CNNC) and China Guangdong Nuclear Power Holding (CGNPH). The project risk is assumed by the contractor in this model.

The third financing model is called the model of cooperative or hybrid financing. This model is also known as Mankala following Finland's experience. Large industrial consumers take part in the NPP capital and in proportion receive a quota and an obligation to buy the produced electrical energy. Additional funds are ensured by the EPC contractor, banks and export credit agencies (OECD, 2017). In case of surplus electricity, part of it may be sold on the free market. The advantages of the model are guaranteed prices for the consumers, which are independent of the volatility of the liberalized market and the dispersion of risk among the participants in the project company. Besides, the plant provides lower prices as it does not work to generate profit. This model is used for NPP Fennovoima and NPP Olkiluoto 3 in Finland. The shareholders in NPP Fennovoima are E.ON with 34% participation in the capital and a consortium of 69 Finnish energy and industrial companies from the mining sector, steel production and trade, as well as municipal and regional energy companies. This consortium forms 66% of the NPP capital.

A similar practice is applied in France by Exeltium, which is a consortium of 26 electricity intensive French companies (Lucet, 2015). They started negotiations with EDF in 2006 for signing a long-term contract for buying electrical energy against provision of funding (take-or-pay contract). The contract was signed in 2008 under the following conditions – total financing of 4 billion EUR within 24 years and provision of 311 TWh. The first stage began in 2010 as Exeltium provided in advance 1.7 billion EUR, with the obligation to buy 148 KWh in the next 24 years at the price of 42 EUR/KWh, as the mechanism for price indexation is clearly set. The second stage of the project scheduled to commence in 2011 was postponed due to the decrease in the prices for the coal electricity production and the 2008 financial crises.

The forth model – the project financing is also known as limited recourse financing. A Special Purpose Vehicle – SPV is established that becomes the project owner. The contractor, other sector companies and financing institutions can be shareholders in the SPV. Banks provide long-term credits to the project company backed usually by the assets and guarantees for the project future cash flows. The project risks are clearly identified and traceable. The crediting party assumes larger part of the risk in this model, which makes the finding of such institutions difficult. Such financing has not been applied yet for nuclear projects and there is very little likelihood in the foreseeable future (IEA/OECD/NEA, 2009).

In the last years, under the new conditions, there is a crisis in the four models for NPP financing. New models start to develop and be used in order to fill the vacuum. Such are the cases of NPP financing in the United Kingdom and Turkey.

In the United Kingdom during the construction of Hinkley Point C NPP two instruments are used - state-backed loan and contract for difference (IAEA, 2018). The project envisages the construction of two EPR reactors with capacity of 1,630 MW each. The project value is approximately 19-20 billion GBP. The French company EDF is the contractor. It organizes a project company which owns 66.5%, and the remaining part of the capital of 33.5% is held by two Chinese companies - CNNC and CGN. The Chinese companies take part only in the financing, and not in the plant construction.

The British government backs a loan of 17 billion GBP. The entire financing of the project will be secured by the loan, sale of non-strategic assets, and emission of corporate bonds by EDF. The contract for differences to be signed guarantees an indexed strike price of £92.50/MWh (2012 prices) for 35 years from the end of construction reducing to £89.50/ MWh (2012 prices) if EDF takes a final investment decision on their proposed Sizewell C project. The contract for differences ensures the payment of a subsidy by the government in case the market price is below the strike price. In the reverse case, EDF will return the difference above the strike price to the government.

The NPP Akkuyu project in Turkey envisaged the construction of 4 units VVER type, each with 1,200 MW capacity. The construction began in 2018 by using the model „Build - Own - Operate - BOO". Here the project contractor assumes the commitment to find financing, build, operate and maintain the plant. A project company was established to that end, as initially the contractor Rosatom was supposed to own 51%, and the remaining 49% to be owned by Turkish energy companies (Atiyas, 2012). This idea does not happen and Rosatom becomes the sole owner of the project company's capital. This company will receive financing amounting to 22 billion USD from Russia. The Turkish state company TETAŞ guarantees a buyback contract for 70% of the electricity produced by units 1 and 2, as well as 30% of the electricity produced by units 3 and 4 for the first 15 years of operation at an average price of 123.5 USD/MWh. The remaining quantity will be sold on the market. After the end of the buyback contract 20% of the company's profit will be provided to Turkey (Schneider § Froggatt, 2018).

The financing of nuclear projects should not be regarded as static and firmly set in the preparatory project phases. These projects are very long and risk curve varies in the different NPP lifespan phases, which may be used for favourable crediting of the NPP construction and operation. For example, after the completion of the construction phase the construction risk disappears and that may be used for attracting a new shareholder or refinancing at more favourable conditions than the initial ones.

3. Aspects in building a financial model for determining the viability of a new project for NPP construction

The purpose of the model is to determine the viability of a project for NPP construction and operation – outlining the critical values and assumptions, which make the project viable. The financial model should be structured in such a way so as to encompass the entire information needed to the financial analysis, namely: input parameters, production program and outcomes.

The input parameters cover a wide set of assumptions for: project timing – building and operation; operation and power load (e.g. duration of the working cycle with one nuclear fuel loading; duration of short-term, mid-term and long-term forced outage; dispatching rate; investment costs; depreciation and reinvestments; net working capital; credit parameters; electricity prices; debt/equity ratio.

The assumptions are traditionally developed in several options and their combining leads to the forming of different scenarios for the construction and operation of an NPP. As a minimum the scenarios must study the viability of the model in the different options of the debt/equity ratio, prices and value of investment costs.

The production program includes the calculation of the amount of produced electricity, the operation revenues and costs.

The data generated by the model enables the evaluation of the LCOE and evaluation of the Net Present Value (NPV) and the Internal Rate of Return (IRR) of the project.

Evaluation of the LCOE

The LCOE is the ratio of the discounted project costs and the amount of the produced electricity for the entire project reference period.

The indicators is uniform for the entire project i.e. there are no options or scenarios for it. The indicators is calculated based on the following formula:

$$LCOE = \frac{\sum (Capital_t + O\,\&\,M_t + Fuel_t + D_t) * (1+r)^t}{\sum MWh_t * (1+r)^{-t}},$$

where:

$Capital_t$ – is the total project capital costs for the year t

$O\&M_t$ – is the total operation and maintenance costs for the year t

$Fuel_t$ – is the total costs for nuclear fuel for the year t

D_t – is the total costs for management of nuclear waste and decommissioning of nuclear facilities for the year t

MWh_t – is the total produced amount of electricity for the year t

$(1+r)^{-t}$ – is the discount rate for the year t.

The value of this indicator shows the price at which the project becomes profitable *(break-even),* i.e. the project starts to generate enough cash flows not only to cover all costs but also to ensure return on the invested capital that is comparable to the return on alternative investments but not higher. This approach eliminates the need to project the future electricity price levels, which implies a degree of uncertainly and often depends on political decisions, non-market decisions, subsidies, etc.

Evaluation of the NPV and the IRR

The project NPV is calculated through discounting the nominal net cash flows by applying an adequate discount rate. The NPV value is significantly influenced by the applied discount rate, the duration of the project reference period as well as the price level. In this relation it is presumed that if the NPV is a positive value then the project is profitable.

The project IRR is the discount rate at which the project NPV equals 0. The project is profitable if the IRR equals or is higher than the discount rate applied in the calculation of the NPV.

Both indicators are calculated as follows:

Net cash flow = EBITDA – Capex – CWC – T,

where:

EBITDA (Earnings before interest, taxation, depreciation and amortization) is the difference between the project revenues and costs before the payment of the interests and the accounting of depreciation)

Capex – is the project capital costs

CWC – is the change in working capital

T – is the value of corporate tax.

A key moment in the calculation of NPV and the evaluation of the IRR is the applied discount rate. The setting of an adequate discount rate requires analysis of the Weighted Average Cost of Capital – WACC. The cost of the capital depends on the sources of financing (debt/equity ratio) and the return that these financing sources get as compensation for providing this financing. The financing institutions seek lower return on their funds considering the fact that they are ahead of the private investors on the “queue” for receiving funds (the payments on interest and principal are done before the calculation of profit and the payment of the dividend). The persons advancing equity get return in the form of dividends (in case of sufficient positive cash flows) or in the form of eventual growth in the price of their shares, which depends on the market trends.

The WACC is determined by applying the approach that the capital costs of a company are the average weighted value of the costs for the equity and the costs for the debt, as follows:

$$WACC = \frac{E}{(D+E)} * \mathrm{Re} + \frac{D}{(D+E)} * Rd * (1 - Tc),$$

where:

WACC – is the weighted average costs of capital

D – is the amount of debt financing

E – is the amount of equity financing

Re – is the return that is sought by the persons advancing equity

Rd – is the price of debt

Tc – is the corporate tax rate.

The price of debt (Rd) is calculated through the calculation of the IRR of the financial flow of the debt. This flow includes all debt parameters: initial fee; utilized funds for each year; interest during construction; commitment fee on the non-utilized amount of the loan; repayments on the interest and principle. These amounts are allocated depending on the years in which they occur and based on this the IRR of the financial flow of the debt is calculated. The parameters considered in the calculation of the price of debt depend on the total amount of the investment, the debt/equity ratio and the loan conditions.

The return that is sought by the persons advancing equity - R_E, is determined by the application of the *Capital Asset Pricing Model (CAPM)*. This is a standard theoretical framework for evaluation of the sought return from equity. The model presumes that the return from equity may be determined as a sum of: the value of return from non-risk financial instruments; risk supplement for the country (e.g. asymmetrical risk connected with the country); supplement for business risk; and a supplement for asymmetrical project risk.

4. Conclusion – applications for Belene NPP

The conclusions from the analysis related to the Belene NPP project are in several directions:

- The reduction of market risk could be achieved by signing of contracts for difference and contracts for buying the produced electrical energy at previously determined price. These risks are assumed by the government. Due to the significant political element in the nuclear projects the commitment of the government is a necessary condition for the success of these projects.

- The ensuing of the necessary project financing often becomes a commitment of the contractor of the EPC contract. If this funding is not entirely provided by the government, then the contractor will have to raise funding from the widest possible range of financing institutions. This range encompasses investment banks and funds, development banks and export credit agencies. There are also used state guarantees for obtaining such credits. The contractors themselves may provide funding by issue of corporate bonds. The financing of nuclear projects is attractive also for large industrial users, energy companies and even for neighbouring countries which could ensure electricity for a longer period at certain conditions.
- If a decision is made that the construction and the operation of Belene NPP is to be done by a private contractor without any state participation then the capacity of the state institutions control and regulate its activity should be assessed.
- The financing of nuclear projects should not be regarded as a fixed process. Depending on the project progress and the financial markets there could be used also other instruments like refinancing, sale of the share of the project company's capital and attracting new investors in it.
- The financial model for calculating the viability of a nuclear project is a complicated combination of assumptions as input parameters, the production program and the final outputs. The minimum criteria in the selection of a nuclear project should be the positive cash flows and an internal rate of return that is higher than the discount rate applied.

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