Determining the Reasonable Degree of Specialization of Russian Companies Participating in NPP Construction Abroad

Peter Grabovy and Vitaly Berezka
Moscow State University of Civil Engineering, Yaroslavskoe shosse, 26, Moscow, Russia
E-mail: v.berezka@hotmail.com

Abstract. NPP construction projects are distinguished by long construction periods (5-7 years), huge investments (up to 30 billion US dollars), and exposure to negative factors affecting the entire commissioning period and project cost. The complexity of the project management of such mega-project requires a set of special techniques and strong analytical and methodological support of decision-makers. The article discusses the practical aspects of identifying a reasonable degree of specialization of participating contractors. For an assessment of the contractor’s specialization level, the process specialization degree ($D_{sp}$) indicator used. It describes the share of key types of works in their total volume, performed on their own. Construction company’s specialization considered as a vehicle ensuring the fullest application of state-of-the-art achievements of the construction science and technology in order to achieve the best technical and economic performance indicators of specialized entities, including improved labor productivity, reduced cost of works, maximized profit. The optimum specialization level and a degree in case of construction of major power complexes were assessed using the example of Belarus NPP chosen as a representative facility. The proposed approach to the determination of a reasonable degree of specialization allows construction entities to plan this parameter for short-term or long-term periods, to assess the economic efficiency of the specialization, subject to its increasing degree. As the achieving of the specialization degree is conditioned, the reasonable $D_{sp}$ delimitation is essential not only in economic but also in social terms. This article will be useful for the management of engineering, design, and contracting companies planning their participation (or already involved) in the investment and construction project in foreign countries.

1. Introduction
The construction of nuclear power plants (NPP) is an important area in the development of the world power generating industry. Over the past decades there has been a steady increase in the volume of construction of nuclear power plants due to the implementation of large energy projects in developed and developing countries. The world market has been developing thanks to the evolutionary expansion of nuclear power generation in countries with experience in operating nuclear power plants, as well as to the attraction of new countries to participate in nuclear power generation industry.

According to the IAEA (Figure 1) [1], 52 nuclear power reactors were under construction in the world in 2019 in 18 countries with a total amount of investments exceeding 150 billion US dollars.
Figure 1. Global number of nuclear reactors under construction by country as of 2020

Russia has a developed scientific, technical and industrial base, references and experience in implementing projects for the construction of large-capacity nuclear power plants in the Russian and international target markets. The portfolio of foreign orders of Rosatom State Corporation includes 36 NPP units in 12 countries [2] – it is the world’s largest nuclear engineering business with a 30% share of the global NPP construction market. Its geographic reach covers Europe, the Middle East, Asia, North Africa, and the Asia-Pacific region. One of Russia’s biggest systemic corporations, Rosatom State Corporation, implements a number of investment projects abroad (table 1) [3-4].

Table 1. Foreign NPP construction projects by Rosatom State Corporation

| Russian stakeholder | Country     | Key projects                  | Implementation years | Project type                                      | Investment, billion USD |
|---------------------|-------------|--------------------------------|----------------------|--------------------------------------------------|-------------------------|
|                     | Belarus     | Belarus NPP                   | 2011-2020            | 2 power units VVER-1200, erection phase          | 11,0                    |
|                     | Finland     | NPP Hanhikivi 1              | 2016-2028            | 1 power unit VVER-1200, erection phase          | 7,0 – 7,7               |
|                     | Hungary     | NPP Paksh II                  | 2019-2031            | 2 power units VVER-1200, erection phase          | 14,0                    |
|                     | Turkey      | NPP AKKUYU                   | 2010-2023            | 4 power units VVER-1200, erection phase          | 22,0                    |
|                     | Iran        | NPP Busher 2, 3              | 2016-2026            | 4 power units VVER-1000, erection phase          | 11,0                    |
| Rosatom State       | China       | Tienwan NPP – 3, 4, 7, 8     | 2011-2019            | 2 power units VVER-1200, erection phase          | 10,4 (6,1 and 4,3)     |
| Corporation         | India       | NPP Kudankulam 3, 4          | 2002-2025            | 2 power units VVER-1000, erection phase          | 9,5                     |
|                     | Egypt       | NPP El Dabaa                 | 2015-2026            | 4 power units VVER-1200, initial erection phase  | 30                      |
|                     | Bangladesh  | NPP Ruppur                   | 2015-2024            | 2 power units VVER-1200, erection phase          | 13                      |
For Russia, implementation of NPP investment and construction projects abroad is a promising area, as part of the task to increase the atomic power industry’s export potential, subject to the global environment, national competitiveness, and market positions achieved.

The Rosatom State Corporation’s engineering division, headed by ASE IC JSC, has advanced competences in the management of erection projects of complex engineering facilities. Currently, the Engineering Division specializes primarily in the implementation of projects implying erection of high-capacity NPP in the Russian and international markets. At present, the Rosatom State Corporation’s engineering division is the world’s leader in the nuclear engineering business; its global NPP construction market share is 30%. Business geography covers Europe, the Middle East, Asia, North Africa, Asia Pacific.

Russian facilities include: Novovoronezhskaya NPP-2, Rostov NPP, Kursk NPP-2, Leningrad NPP-2. Foreign projects account for about 80% of the Engineering Division’s revenue.

Project owners are countries intending to diversify their power balance, provide cheap electric power to their economy.

Part of the company’s core business is the construction of high-capacity NPPs. In this connection, the Rosatom State Corporation’s Engineering division provides project management, designing, equipment supply, NPP construction services.

One of Rosatom’s strategic goals is the increase of the construction share of high-capacity nuclear stations in international markets. An indispensable requirement thereof is the unconditional compliance by the Engineering division with their contracts according to the specified parameters. Meeting the timelines and the cost of NPP construction is the company’s absolute business priority. This goal is achieved mainly by [2, 4, 10]:

- Continuous improvement of operating and project management processes;
- Using efficient digital tools and information systems throughout the project’s lifecycle – from pre-contract works to the NPP commissioning;
- Quality improvement at every stage of NPP construction;
- Key staff development.

Authors had analyzed several studies and reports on the international NPP project construction management [14, 16, 17, 18], associated risk assessments and risk management approaches [11, 12, 13, 15, 22] and best project management practices [19, 20, 21, 17].

Specialization is a form of social differentiation of labor, consisting in the concentration of construction entities on the performance of works of same type, or on the erection of facilities of same purpose.

Specialization forms are important for the production engineering. Their economic efficiency, consisting primarily in the improved labor productivity, increases with the narrowing of the range of works performed, and with the free resource interchange ensured at the given specialized unit. [5-6]

2. Materials and method
There are four specialization forms: branch, object, process, and detail specialization [5-6].

Branch specialization provides for identification of entities specialized in the construction of buildings and facilities of a certain type for individual sectors of national economy. This specialization exists at the ministry level.

Object specialization means establishing economic units specialized in the construction of buildings and facilities having common volume-structure modules, such as nuclear power plants (NPP), transportation facilities, etc. This form of specialization exists at the level of major construction and real estate development firms.

Process specialization implies the focusing of construction units on the execution of certain types of works united by the technology and the organization, resulting in the completion of a certain construction phase (e.g., in the case of NPP, erection of the reactor compartment, special building, concrete, finishing, heating mounting works, etc.). This form has developed at the level of specialized construction companies, process flows, process areas.
**Detail specialization** means breaking the consolidated construction process down into a number of individual sub-processes, and concentration of production at individual units (e.g., production of building structures at reinforced concrete and metal structure plants, finishing parts – at the grounds of construction companies; erection of building structures, brick- and stonework – at the erection section), which ultimately turns the building site into an erection site. The detail specialization is developed at the level of specialized units, crews, shifts.

In NPP construction, process specialization has become widespread, namely in mechanized earthworks, installation of building structures, sanitary engineering, electrical, finishing, road, equipment assembly and other works. In this respect, the process specialization is the most efficient one. Currently, contractors participating in the construction of NPP which use this approach gain the maximum economic benefit (Table 2).

**Table 2. Number of contractors participating in NPP construction in Russia**

| Name of NPP               | Number of contractors* |
|--------------------------|------------------------|
| Beloyarskaya NPP         | 58                     |
| Rostovskaya NPP          | 50                     |
| Novovoronezhskaya NPP-2  | 51                     |
| Leningradskaya NPP-2     | 32                     |
| Baltiyskaya NPP          | 20                     |

* as of 01 Jul 2013, reported by Concern Rosenergoatom JSC

At the same time, some negative aspects can also arise in connection with the specialization. With its deepening, the number of organizationally separate construction participants, the geographic dispersion of business entities, and the number of external relations due to cooperation increase, which finally lowers the project management level and worsens economic indicators. Thus, the reasonable level and the optimum degree of specialization of process- or object-specialized companies and units should be defined [7-9].

**Organization of a new construction as exemplified by Hanhikivi 1 NPP project in Finland.**

The Fennovoima OY company has acquired the “turn-key” project and will construct Hanhikivi 1 nuclear power plant in Puhjajoki during 2016-2028. NPP supplier is RAOS ProjectOy, forming part of the Rosatom State Corporation. The Fennovoima OY is in charge of designing, construction, erection and commissioning of NPP. Total investment cost will be EUR 6.5 to 7 billion, which includes initial NPP construction costs, financing and waste management costs. The cost estimate has not changed since Spring 2014, where the initial investment decision was made.

The nuclear power plant consists of a reactor building, a turbine building, a control point building, and fuel buildings, among others. The biggest number of people involved in the construction of the nuclear power station at a time will be about 4,000 persons. An infrastructure and auxiliary buildings will be built on the Hanhikivi building site, totaling to EUR 400 to 500 million. As of September 2019, about 230 persons work every day on the building site. The building site management system includes 600 companies, of which 560 are Finnish. About 3,000 people have been trained on the access to the building site. [25]

The project’s general contractor is RAOS ProjectOy which, in turn, will contract sub-contractors. Some of them are the Russian companies: Concern TITAN-2 JSC, Atomproject JSC, Atoenergomash JSC, and HYDROPRESS EDB.

Within the period from the commencement of the project preparation phase, from July 2015 to September 2019, the general contractor, CONCERN TITAN-2 JSC, has conducted 35 subcontracting
tenders for the following works: construction of electricity supply networks, dredging, survey and design, excavation of pits for main buildings and structures, earthworks and installation of site networks, etc.

The level of specialization defines the consolidation of a uniform production process, made by excluding same-type and technologically-related works (or individual construction categories) from the business area of general construction companies, and allocating the same to separate specialized units. The consolidation of such uniform production facilities provides the opportunity for further labor differentiation, work separation and allocation to newly established specialized companies or units, i.e. further deepening of specialization degree takes place. The specialization deepening process is the splitting of consolidated works or construction categories into their component parts. Conventional limit of process specialization degree is the execution of only one type of works by a particular construction company (e.g., concrete or finishing works). Assessing the level and choosing the reasonable specialization degree ensure further improvement of the operating performance of construction companies and their units (Figure 1).

NPP project is a set of related measures, intended to achieve the goals set within a given period and within a fixed budget [10]. Typical cost structure of a two-unit NPP consist of equipment (42%) and construction and installation (42%). The project structure is defined by the entirety of interrelated elements and links between them, forming a product-oriented “tree” of components, including equipment, works, services, and information (Table 3).

| Table 3. Number of works at various levels of NPP construction schedules |
|---------------------------------------------------------------|
| **NPP erection** | **1st level schedule – key phases of the investment project** | **3rd level schedule – “Owner – General Contractor” master schedule** |
| Number of works | 1 000 | 150 000 |
| Number of ancillary work identification codes | 100 | 100 |
| Average resource number | 6 | 6 |

The specialization level required to implement NPP project depends on project members, their specialization degree; allocation of functions and responsibilities depends on the type, category, scale, complexity and lifecycle phase of the project.

Functions of NPP project are broken down by project goals management (object area); time management, cost management, quality management, risk management, contract management, stakeholders and staff management, relations and data flow management [1].

3. Results
The optimum specialization level and degree in case of construction of major power complexes were assessed using the example of Belarus NPP chosen as a representative facility. The Belarus NPP is being constructed by a general contractor, with more than 30 subcontractors involved. Operations of three construction entities were analyzed: monolithic concrete was cast by Subcontractor-1, 2, 3 (or SC-1, SC-2 and SC-3). The specialization level (Ls) of these organizations has achieved virtually its maximum limit in the last 8 years — 92 to 96% at the average. In this connection, it is quite difficult to plan any further Ls increase. To assess the specialization level in a more objective way, the “process specialization degree” ($D_{SP}$) indicator should be used, which describes the share of key types of works in their total volume, performed on their own. The $D_{SP}$ value is calculated using the formula:

$$D_{SP} = \frac{\sum_{j=1}^{n} W_j}{\sum_{j=1}^{n} W_j}$$

where $W_j$ is the volume of work $j$, and $n$ is the total number of works.
\[ D_{SP} = 0.01 \sqrt{\sum_{i=1}^{n} (Q - \bar{Q})^2} \]

where \( n \) is the number of \( i \)-th processes of key types; \( Q \) is the share of the work volume of the \( i \) process in the total volume of works in value terms; \( \bar{Q} \) is the arithmetic mean of shares of all processes.

The \( D_{SP} \) value varies within \( 0 \leq D_{SP} \leq 1 \), with its reasonable value depending on a number of factors, such as: specialization profile, specialized units’ operating conditions, labor organization forms, etc.

Data on changes in the process specialization degree by years of construction are given in table 4.

| Table 4. Process specialization degree (imitational (adapted) dataset for demonstrational purposes) |
|-----------------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Company | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   | 2017   |
| Subcontractor-1 | 0.325  | 0.375  | 0.44   | 0.502  | 0.503  | 0.526  | 0.568  | 0.810  |
| Subcontractor-2  | 0.58   | 0.61   | 0.72   | 0.84   | 0.87   | 0.90   | 0.92   | 0.95   |
| Subcontractor-3  | 0.23   | 0.35   | 0.48   | 0.606  | 0.74   | 0.75   | 0.82   | 0.84   |

The analysis of key technical and economic production and business performance indicators of the above entities for the same period shows than annual plan in terms of the volume of building and assembly works (BAW), output, cost and revenue was met and even exceeded by all the three entities.

At the same time, monthly schedules of BAW actually completed evidence that the main principles of the straight-line construction – even and regular execution of works – were not followed by the entities. So, in the last months of every quarter, half-year and year, the volume of works completed exceeded the yearly average 1.5 to 2 times. Given that the number of staff of the construction units was stable, such facts evidence the existence of considerable unused reserves for further improvement of the organization of the NPP construction.

The practice shows that the existence of such reserves is due to time losses at the “joint” of main work types in connection with complicated cooperation relations. External time losses are caused by untimely making available the working area, design specifications and estimates, equipment; while intra-corporate losses – by untimely delivery of materials, lack of trucks and devices, labor misconduct.

Time losses (table 5) are equivalent to yearly BAW shortfall for almost RUB 100 million.

| Table 5. Dynamic of subcontractor performance indicators (imitational (adapted) dataset) |
|-----------------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Year of construction | Labor productivity, KRUB/year | Breakeven level, % | Time losses, % |
|                      | SC-1   | SC-2   | SC-3   | SC-1   | SC-2   | SC-3   | SC-1   | SC-2   | SC-3   |
| 2010                 | 8.3    | 10.5   | 8.4    | 8.1    | 5.4    | 4.3    | 5.8    | 4.9    | 10.4   |
| 2011                 | 10.3   | 10.6   | 10.2   | 20.3   | 8.1    | 4.7    | 4.9    | 4.7    | 9.4    |
| 2012                 | 11.9   | 16.0   | 10.3   | 26.1   | 12.0   | 7.4    | 3.7    | 4.1    | 9      |
| 2013                 | 13.3   | 21.4   | 11.7   | 27.2   | 14.8   | 8.6    | 3.7    | 3.9    | 8.7    |
| 2014                 | 15.3   | 22.4   | 14.7   | 27.7   | 15.5   | 8.2    | 3.6    | 3.7    | 9.1    |
| 2015                 | 15.6   | 23.1   | 16.8   | 20.6   | 15.5   | 7.5    | 3.1    | 3.9    | 10.4   |
| 2016                 | 15.4   | 19.6   | 13.9   | 20.1   | 15.4   | 7.1    | 4.3    | 4.1    | 10.8   |
| 2017                 | 15.9   | 23.2   | 16.5   | 20.1   | 15.1   | 7      | 4.9    | 4.2    | 10.8   |
The numerous options of the process specialization development within a system deemed isolated (including the entirety of construction entities involved in the NPP erection) and the need to choose most optimum threshold values of the $D_{SP}$ (at which, best technical and economic indicators are achieved) require a scientifically grounded approach to the solution of the issue in question. The accounting and modeling of the impact of various factors upon the process specialization degree parameters can be undertaken using the economic statistics method, based on the detection of correlation dependences between the degree of construction units’ process specialization, and their performance criteria for a historic period.

Usually, the BAW cost ($C$), labor productivity ($B$), or a combination of indicators (cost ($C$) and profitability, labor productivity ($B$) and breaken level ($P$), etc.) are used as such indicators. In fact, the deepening of the process specialization contributes to the improvement of the labor productivity and reduction of work cost. However, along with positive results, adverse effects of the specialization appear; in particular, time and resource losses at the “joints” between main work types (or process operations) increase in connection with the complicated cooperation relations and the reduced reliability of the construction operating management. Therefore, the impact of the $D_{SP}$ upon not only the labor productivity “$B$” and breakeven level “$P$”, but also upon time losses “$\Pi$” at the “joints” of main types of works undertaken by various process-specialized construction entities (units) should be considered.

Studies undertaken in other construction industries evidence that the relation between construction units’ performance indicators and the $D_{SP}$ is approximated by a parabolic function (second-order parabola):

$$
\begin{align*}
B &= a_1 + B_1 D_{SP} + C_1 D_{SP}^2; \\
C &= a_2 + B_2 D_{SP} + C_2 D_{SP}^2; \\
\Pi &= a_3 + B_3 D_{SP} + C_3 D_{SP}^2.
\end{align*}
$$

The type of these dependences as shown in fig. 2 allows identifying a certain area of reasonable threshold values $D_{SP}(\text{reas})$, where relatively low work cost and time losses are ensured at the highest labor productivity.

The problem of finding the reasonable degree of process specialization can be resolved graphically (figure 2 and figure 3).

Figure 2. Dependence of labor productivity $B$, works cost $C$ and time losses $\Pi$ on the degree of process specialization $D_{SP}$
Figure 3. Dependence of labor productivity “B”, breakeven level “P” and time losses “П” on the degree of process specialization $D_{SP}$.

The diagram (figure 3) shows the dependence of the breakeven level, labor productivity, and time losses on the degree of process specialization for Subcontractor-1, Subcontractor-2 and Subcontractor-3. As shown by the analysis, the degree of process specialization of each specific entity depends on the number of work types undertaken, production concentration level, number of staff, and the so-called transit line of the entity. The transit line means the area of optimum values of functions, delimited by $D_{SP}$ threshold values, describing time losses, labor productivity, and breakeven level. This area is at the same time the reasonable area of allocation of work types undertaken by the construction entity. For example, in the case of Subcontractor-2, the $D_{SP}$ area of (0.85—0.93) is reasonable.

The analysis revealed the following rule: a certain reasonable area of the specialization depth is matched by most efficient technical and economic performance indicators of a construction unit. This common rule is called “bifurcation law” or “transit line law”. The law can be used to analyze construction contractors’ performance (figure 4), as it expresses the close direct relation between technical and economic indicators, and the optimum specialization degree. Those indicators which are independent from the $D_{SP}$ and reflect secondary effects do not follow the transit line law.
4. Conclusions and discussion

NPP project management is the art of governing and coordinating human, financial and material resources, using state-of-the-art management methods and techniques, organizational forms of production and construction, for the purpose of achieving the project deliverables in respect of the work scope and content, cost, time, quality and satisfaction of the project stakeholders’ goals.

Development of a construction company’s specialization should not be a goal in itself; instead, it should be considered as a vehicle ensuring the fullest application of state-of-the-art achievements of the construction science and technology, in order to achieve the best technical and economic performance indicators of specialized entities, including improved labor productivity, reduced cost of works, maximized profit.

As shown in fig. 4, some indicators (output, earnings, profitability, works cost, time losses, economic effect) match the most favorable specialization degree. If values of technical and economic indicators are plotted on the general graph in the system of coordinates, this match will be evidenced by the fact that all extremums of functions will be located in the same area at a certain specialization degree. Each curve has an area of most favorable indicators for the given construction unit, ensuring the maximum output, earning, minimum time losses, etc.; i.e. the transit line law states that the optimum specialization degree corresponds to a set of extreme values of output, cost, earning, etc.

The degree of the process specialization increases with the decrease in the number of work types allocated to any given specialized entity, and with the increase in the scope of same-type works and in the scope of works performed on the same facility. Based on the above, functions shown in fig. 1 allow forecasting the recommended degree of specialization for building and erection companies, in order to achieve maximum output, profitability, and to minimize time losses. This approach allows improving technical and economic performance of NPP construction. строительства NPP. That’s why in the construction of Belarus NPP, in the last 8 years, at relatively constant specialization level, the specialization depth has increased 3 times.

The proposed approach to the determination of a reasonable degree of specialization allows construction entities to plan this parameter for a five-year, a year, a quarter period, to assess the economic efficiency of the specialization, subject to its increasing degree. As the achieving of the specialization degree is conditioned, among other things, upon the team’s potentialities, the reasonable $D_{SP}$ delimitation is important not only in economic, but also in social terms.
References

[1] IAEA's NUCLEUS information resource. International Atomic Energy Agency [Electronic source] URL: https://www.iaea.org (date of access: February 1, 2020)
[2] Rosatom State Corporation [Electronic source] URL: https://www.rosatom.ru (date of access: February 1, 2020)
[3] Russia's Energy Strategy for the Period up to 2030 approved by order of the Government of the Russian Federation of November 13, 2009 No. 1715-p.
[4] Rusatom Overseas JSC; [Electronic source] URL: http://www.rusatom-overseas.com/ (date of access: October 1, 2019).
[5] Surovtsev B A 1987 Spetsializatsia stroitel'nogo proizvodstva [Specialization of construction production] (Leningrad: Stroyizdat) p 32
[6] Zadorozhniy D V 1988 Ratsionalnie formi organizatsii slozhnikh inzhenernikh soorugeniya mobilnymi podrazdeleniyami [Rational forms of organization of construction of complex engineering structures by mobile units] PhD dissertation (Moscow: Moscow Institute of civil engineering) p 10
[7] Grabovy P. G., Berezka V.V. 2019 Upravleniye organizatsionno-technologicheskimi (operatsionnimi) riskami rossiyskimi podryadchikami pri soorужении AES za rubezhom [Management of Organizational and Technological (Operational) Risks Faced by Russian Contractors in the Course of Nuclear Power Plants Construction Abroad] Nedvizhimost: economica i upravlenie (Real Estate: economic and management) issue 3, p 6-17
[8] Chernyakhovskaya Y.V., Berezka V.V. 2019 Russian business strategy and tactics on the world market of NPP construction (economic system) [Rossiyskaya strategiya prodazh invesititsionno-stroitel'nykh proyektov sooruzheniya AES (ekonomicheskikh sistem) na mezhdunarodnom rynek] Nedvizhimost: economica i upravlenie (Real Estate: economic and management) issue 2 p 53-60.
[9] Berezka V.V., A. Roehrl 2019 Osobennosti upravleniya proyektami i riskami podryadchika pri osushchestvlenii stroitel'stva v zarubezhnykh stranakh [Features of project management and contractor risks in the implementation of construction in foreign countries] Nedvizhimost: economica i upravlenie (Real Estate: economic and management) issue 1 p 13-18.
[10] Chernyakhovskaya Yu. V. Integrated sales of nuclear power plants for the sustainable development of the nuclear industry // Economic Sciences. 2015. No. 11 (132). P. 24-27
[11] Grabovy P.G. et al. Risks in modern business. Textbook / under the general editorship by Grabovy P.G.-M.: “ASV”, “Prosvetitel”, 2017.
[12] Avilova I.P., Strekozova L.V. Retrospective approach to the assessment of organizational and technological risks of an investment construction project, Real Estate: Economics, Management, Moscow, 2013
[13] Popelnyukhov S.N. Risk management methodology in the organizational and economic system of a developer during the implementation of foreign investment and construction projects, Monograph, Moscow, 2013.
[14] D. Schlissel, B. Biewald, Nuclear Power Plant Construction Costs, Synapse Energy Economics, July 2008
[15] J. Waletowski, G. Gibson, International Project Risk Assessment: Methods, Procedures, and Critical Factors, Center construction industry studies, The University of Texas, 2003
[16] R. H. Neale Managing International Construction Projects: An Overview // International Construction Management Series, No 7, 1995.
[17] G. Locatelli “Why are Megaprojects, Including Nuclear Power Plants, Delivered Overbudget and Late? Reasons and Remedies”, Report MIT-ANP-TR-172, Center for Advanced Nuclear Energy Systems (CANES), Massachusetts Institute of Technology, 2018
[18] International Atomic Energy Agency, Nuclear Power Project Management, Technical Reports Series No. 279, IAEA, Vienna (1988).
[19] PMBOK® Guide – Sixth Edition (2017)
[20] Structuring Nuclear Projects for Success An Analytic Framework – WNA Report

[21] S. Alsharif, A Framework for Identifying Causal Factors of Delay in Nuclear Power Plant Projects, International Conference on Sustainable Design, Engineering and Construction, Procedia Engineering 145 (2016) 1486 - 1492

[22] M. Mufazzal, Construction schedule delay risk assessment by using combined AHP-RII methodology for an international NPP project, KEPCO International Nuclear Graduate School (KINGS), 2015

[23] Nuclear Energy Industrial Complex Joint Stock Company; [Electronic source] URL: http://atomenergoprom.ru/ (date of access: October 1, 2019).

[24] Topical at the construction site of Fennovoima OY, https://www.fennovoima.fi/en/hanhikivi-1/topical-construction-site

[25] Global Construction 2030 – A global forecast for the construction industry to 2030 // Global Construction Perspectives Limited and Oxford Economics Limited, 2015;