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The Methodology of Cost Estimation for Decommissioning Nuclear Facilities in the Russian Federation

International Expert Feedback on the Methodology Developed by ROSATOM

Final Report

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The mission of the NEA is:

- to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally sound and economical use of nuclear energy for peaceful purposes;
- to provide authoritative assessments and to forge common understandings on key issues as input to government decisions on nuclear energy policy and to broader OECD analyses in areas such as energy and the sustainable development of low-carbon economies.

Specific areas of competence of the NEA include the safety and regulation of nuclear activities, radioactive waste management, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information. The NEA Data Bank provides nuclear data and computer program services for participating countries.

Table of contents

Foreword

A major activity of the Nuclear Energy Agency (NEA) is the organisation of independent, international peer reviews and provision of International Expert Feedback (IEF) of national studies and projects. The NEA peer reviews and expert feedback are intended to help national programmes and may also be of interest to others with their comments on issues of general relevance.

It was at the request of the Russian State Atomic Energy Corporation (ROSATOM) that the NEA organised an IEF to assess the sufficiency and applicability of the newly developed methodology of cost estimation for decommissioning nuclear facilities in the Russian Federation based on international guidelines, good practices and strategies of other national programmes.

According to the Terms of Reference, agreed between the NEA and ROSATOM, the purpose of the IEF is to provide an independent review of the ROSATOM Decommissioning Cost Estimation Methodology (hereinafter "ROSATOM Methodology" in this report). The IEF aims to give feedback on the ROSATOM Methodology and its application based on international guidelines, on international good practices and on strategies of other national programmes. The IEF specifically focuses on:

- assessing the cost estimation process in terms of credibility, reliability and auditability;
- assessing the completeness, accuracy and transparency of the outcomes of the application of the methodology.

The NEA Secretariat established a team of six international experts from NEA member states (IEF team) to conduct the IEF, including one member from the European Commission. The experts were chosen to be free of conflict of interest with ROSATOM and to bring complementary expertise to the review, according to the Agreement. A rapporteur supplemented the team of experts for drafting the report. The IEF work was co-ordinated by the NEA Secretariat, members of which also accompanied the IEF team during its working visit to Russia. All contacts between ROSATOM and the IEF were organised and managed through the NEA.

The experts reviewed a number of documents provided in English translation by ROSATOM.

In addition, the IEF team received supplementary information from ROSATOM in answers to questions and in meetings with staff from ROSATOM during the working visit to Russia in September 2016.

This report presents the consensus view of the IEF team.

The IEF team has made its best effort to ensure that all information is accurate.

In keeping with NEA procedures for independent reviews, ROSATOM has not formally commented on this report – although ROSATOM was given an opportunity to check for factual correctness.

Acknowledgements

The members of the International Expert Feedback (IEF) team would like to thank the ROSATOM staff for their hospitality during the visit to Russia, and for the helpful and open way they engaged in the review progress. The IEF team would also like to thank the NEA for their excellent organisational support, which facilitated the team's work.

List of abbreviations and acronyms

FAA	Free access area
IEF	International Expert Feedback
IFRS	International Financial Reporting Standards
ISDC	International Structure for Decommissioning Costing
NEA	Nuclear Energy Agency
NPP	Nuclear power plant
NRI	Nuclear research installations
QA	Quality assurance
ROSATOM	Russian State Atomic Energy Corporation
UGPR	Uranium-graphite production reactors

Executive summary

Introduction

The Russian State Atomic Energy Corporation (ROSATOM) is the national nuclear corporation which was established by the Russian Federation as a state-owned corporation in December 2007. It manages more than 400 organisations and is responsible for the decommissioning of about 2 500 nuclear facilities.

ROSATOM is required to include decommissioning liabilities in its annual International Financial Reporting Standards (IFRS) report. To support this, it has developed the ROSATOM Methodology. In order to gain confidence regarding the alignment of the ROSATOM Methodology with international guidelines and good practices, ROSATOM has requested the Nuclear Energy Agency (NEA) to conduct an international expert review, the so-called International Expert Feedback (IEF).

Statement to ROSATOM

The ROSATOM Decommissioning Cost Estimation Methodology is generally aligned with the International Structure for Decommissioning Costing (ISDC) of Nuclear Installations, and both the methodology and its application reflect current good practices in decommissioning cost estimation.

Based on its review of the ROSATOM Methodology as applied to a nuclear power plant (NPP) example, the IEF team concludes that the methodology is sufficient and credible as a basis for calculating estimates of the costs of decommissioning nuclear facilities in Russia for the purposes of fulfilling its financial reporting obligations.

Further experience in application of the ROSATOM Methodology and feedback from its use would be expected to support ongoing development of the ROSATOM Methodology and facilitate its wider use for planning and financing purposes.

Key findings

ROSATOM Methodology

Key finding 3a: The computational model and data used is suitable for preparing a cost estimate for the purpose of the financial reporting.

Key finding 3b: Separation and regrouping of the management and support costs under item 6 of the ROSATOM Methodology would improve the transparency and visibility of the methodology and facilitate the comparison of the different projects and cost estimate methodologies. The IEF team recommends that overall decommissioning management be considered independently from involvement of contractors in the project (planning, scheduling, quality assurance, etc.). Such a change would also more clearly show the costs associated with decommissioning and site operation.

Key finding 3c: Some rates used in the Classifier result from evaluation of relatively old input data (price information from 1991). This affects the accuracy of the model as present developments in technologies and methods might not be considered appropriately.

Key finding 3d: The investigation of recently developed technologies and methods may be helpful to update the unit prices for some classifiers used in the model and to improve the accuracy of the estimate.

Key finding 3e: The ROSATOM Methodology is using a combination of bottom-up technique and specific analogy technique, which are the first two options in the ISDC system (chapter 2.3). The IEF team considers that this aspect of the ROSATOM Methodology is in line with the one used in the ISDC recommendations.

Key finding 3f: The formulas presented in the reviewed material are clearly presented and easy to understand and follow.

Key finding 3g: All cost categories (labour, expenses, investments and contingencies) are included in the rates. The procedure used in the ROSATOM Methodology simplifies the cost estimation process and gives results which are appropriate for the estimation of an overall budget.

Key findings 3h: To facilitate the application of the ROSATOM Methodology for other purposes such as planning, it would be appropriate to separate the cost categories (labour, expenses, investments and contingencies). This would also make the ROSATOM Methodology more comparable with other cost estimation methodologies, including the ISDC approach and would increase its auditability and transparency.

Key finding 3i: The cost estimation process of the ROSATOM Methodology corresponds to the ISDC description of the process, as presented in chapter 2.5 of the ISDC. Based on the observations of the IEF team, the ROSATOM Methodology is consistent with current good practices and is similar to the methods used in other countries, e.g. in Italy, Germany, etc.

Key findings 3j: It is important to define the boundary conditions and the scope of decommissioning cost estimation precisely. Clear definitions contribute to accuracy and reliability of the ROSATOM Methodology, and facilitate the comparison with other methodologies and cost estimates. The use of clear boundary conditions also facilitates the process of checking that there are no gaps or overlaps in the process estimating of nuclear liabilities.

Key findings 3k: The cost structure hierarchy in general corresponds to the hierarchy of the ISDC. The IEF team noted some differences at the third level of the hierarchy in certain areas and recommends that ROSATOM endeavours to maintain consistency with the ISDC, taking into account the specific features of nuclear facility decommissioning in Russia.

Key findings 3l: The IEF team noted from its review of the structure that there were some indications that the list of classifiers used in the ROSATOM Methodology might not be fully complete and/or may contain some misplacements. The IEF team suggests that ROSATOM consider a further review of the completeness and accuracy of the list.

Key finding 3m: The IEF team suggests that a more comprehensive description of the content of the activities should be included in the documentation as this may help to clarify the issues (works) covered by the individual classifier. In addition, specific

classifier numbers could be added to the headlines in the "feasibility of rates" document. This would make the method more transparent and easy to review.

Key finding 3n: Contingencies are included in the rates. The average contingency is based on expert judgement and information available from the suppliers. The values used in the ROSATOM Methodology l in the range of 3 – 11% and seem to be reasonable. The approach of using contingency is consistent with the ISDC system.

Key findings 3o: For future use of the method for other purposes, it would be beneficial to include risk management elements to the method. This might help to more correctly assess works that are not very well known at the present time (e.g. decontamination of building structures). The IEF team notes that work on addressing uncertainties in decommissioning cost estimation and building on the existing ISDC approach is currently ongoing in a joint IAEA and NEA project, and that the report containing the new guidance is to be published by the NEA in early 2017.

Inputs to the model

Key finding 4a: There are two proposed strategies for NPP decommissioning in the ROSATOM Methodology and they are consistent with ISDC and current IAEA guidance.

Key finding 4b: The treatment of radioactive waste arising from decommissioning is described in a separate methodology guideline. While the IEF team did not review this separate guideline, it noted that such an approach is compatible with ISDC.

Key finding 4c: It was noted that information was collected on costs already incurred in ongoing decommissioning projects. This issue was not considered in detail by the IEF team, as it has less impact in the reporting of future financial liabilities. However, clearly, such information would be highly relevant for further developing the ROSATOM Methodology for other purposes.

Key finding 4d: The definition of the unit costs for the classifier items is documented in a transparent way.

Key finding 4e: The credibility of the process would be further improved by introducing an information quality indicator for each classifier item.

Key finding 4f: The IEF team suggests that it could be useful to develop and document a process to help identify suitable rates that meet an appropriate predetermined quality.

Workflow followed when applying the ROSATOM Methodology

Key finding 4g: Currently the knowledge about the implementation of the ROSATOM Methodology, and in particular the use of the calculation model, resides mostly with the external consultant. The IEF team recognised the value of this during the development phase of the ROSATOM Methodology. The IEF team suggests that ROSATOM consider additional organisational measures to ensure the sustainability of this knowledge, expertise and experience.

Key finding 4h: There are situations where the consultant provides the operator with support to fill in the questionnaire. The IEF team sees such support as valuable for ensuring consistency and for helping when the resources required are significant considering the operator size.

Key finding 4i: The extensive checks and validation of the data by the consultant increase the quality of the input data and enhance confidence in the overall cost estimate.

Key finding 4j: The IEF team is confident that the calculation model will function to produce the estimate as described in the documentation and the presentation delivered.

Key finding 4k: There is an intention to move from the Excel calculation model to a dedicated purpose-built platform. The development of a dedicated calculation tool would be expected to improve the reliability of the estimations. Confidence in the model and its outcome can be enhanced and strengthened by using a quality management system approach.

Key finding 4l: The IEF team appreciates that there is a process lead by ROSATOM to reconcile any differences in opinion that could occur between the various parties involved.

Key finding 4m: The IEF team did not evaluate the reporting of the cost estimate outputs from the methodology as this is not considered an important consideration for the current purpose of the financial reporting of the liabilities. However, it would be useful to develop guidelines on the reporting of the cost estimate, in particular if the ROSATOM Methodology is further developed for other purposes, such as estimates for specific projects. Useful guidance can be found in the ISDC (see NEA 2012, section 4.3) and the "Practice" report (NEA 2015).

Responsibilities

Key finding 4n: The responsibilities between the various entities involved in the process are well defined. The interfaces between the stakeholders are well established. This enhances transparency and confidence in the process.

Quality assurance

Key finding 4o: The external consultant has a key role in the data quality assurance (QA) process, including error correction. The IEF team suggests that ROSATOM consider additional organisational measures to ensure the sustainability of this knowledge, expertise and experience.

Key finding 4p: The IEF team considers that the current QA process is suitable for the current purpose of the cost estimate. Considering the evolving needs of ROSATOM for what concerns the usage of the decommissioning cost estimate, the QA process may need to be further developed to ensure that the quality of the results of the cost estimation process continues to meet evolving requirements.

Organisation of this report

This report is organised as follows. The first section introduces ROSATOM and decommissioning of nuclear facilities in Russia, including its approach to cost estimation, and the work of the IEF; the second section provides the IEF statement to ROSATOM; the third and the fourth sections provide the key findings and analysis from the IEF review of the ROSATOM Methodology and its application, respectively.

1. Introduction

1.1. ROSATOM and the decommissioning of nuclear facilities in the Russian Federation

The Russian State Atomic Energy Corporation (ROSATOM) is the national nuclear corporation which was established by Russia as a state-owned corporation in December 2007.

ROSATOM activities include uranium exploration, construction of NPPs, uranium product enrichment and conversion, and decommissioning. It manages more than 400 organisations, including administrative entities and support infrastructure, and has informed the International Expert Feedback (IEF) team that it is responsible for the decommissioning of about 2 500 nuclear facilities, as summarised in the table below.

Table 1.1. Type of Nuclear Facilities

Type of Nuclear facility	Number of decommissioning objects
Reactor Units	37
Uranium-graphite production reactors (UGPR)	10
Nuclear research installations (NRI)	54
Storage facilities	609
Buildings and constructions	1 260
Nuclear icebreakers fleet	14
Polluted lands (including spoil heaps, mines, boreholes)	466

Source: ROSATOM

1.2. The context and purpose of the methodology of cost estimation for decommissioning nuclear facilities in the Russian Federation

Before 2010, decommissioning costs assessments were site-specific and relied on experts' opinions. There was no structured ROSATOM-wide approach to evaluate decommissioning costs.

In 2010, Russia adopted a new legislation regarding the consolidated financial statements[1]. In line with the requirements of this legislation, ROSATOM started

1. Federal Law No. 208-FZ of the Russian Federation, 27 July 2010.

preparing its own financial statements, which reflects the International Financial Reporting Standards (IFRS) requirements. This legal requirement to report its decommissioning liabilities in the annual financial statements is a major factor leading ROSATOM to develop new approaches to decommissioning cost estimation.

In 2011, ROSATOM developed a preliminary methodology for the annual valuation of the decommissioning costs. This methodology consisted of a generic cost estimation approach and in the documentation provided to the IEF team this is referred to as the "consolidated approach". The main steps of the consolidated approach were:

1. classification of nuclear facilities, starting with the determination of their type and number;
2. development of decommissioning concepts for each type of nuclear facility;
3. definition of the decommissioning stages, such as their duration and the detailed list of activities per stage;
4. determination of cost indexes for each decommissioning activity;
5. decommissioning cost evaluation, to be adjusted through the above-mentioned cost indexes.

This consolidated approach, however, presented some challenges to ROSATOM arising in part due to the limited experience in the decommissioning process and its cost assessment. ROSATOM therefore determined that there was a need for further development of its approach to decommissioning cost estimation. ROSATOM informed the IEF team of a number of underlying reasons that led to a decision to replace the consolidated approach. These included considerations related to a perceived lack of flexibility in the approach (e.g. limited practicality to make adjustments to the list of activities or technologies; limited possibilities to modify cost factor analysis) and the recognition of estimation error in the range of 30-50%. In addition, ROSATOM took note of the development of the International Structure for Decommissioning Costing (ISDC) of Nuclear Installations (NEA 2012), information from other countries on decommissioning costs, and additional decommissioning experience gained by ROSATOM.

ROSATOM therefore determined that there was a need for further development of its approach to decommissioning cost estimation, and started developing the new ROSATOM Methodology in 2014.

The main features of the ROSATOM Methodology were:

- the adaptation of the ISDC to the features of the Russian nuclear industry, for each type of nuclear facility (the ROSATOM "Classifier");
- the development of a methodology for calculation of the decommissioning cost of each type of nuclear facility, in accordance with the Classifier;
- the development of a method for calculation of the cost of radioactive waste management arising from decommissioning.

Aspects of the ROSATOM Methodology are described further in the IEF analysis presented in subsequent sections of this report.

1.3. Organisation and conduct of the International Expert Feedback

In order to provide feedback on the alignment of the ROSATOM Methodology and its application with international guidelines, good practices and strategies of other national

programmes, ROSATOM has requested the NEA to conduct an international expert review, the IEF.

The IEF review specifically focuses on assessing:

- the cost estimation process in terms of credibility, reliability and auditability; and
- the completeness, accuracy and transparency of the outcomes of the application of the methodology.

The IEF was carried out by six international experts chosen by the NEA to be free of conflict of interest and to bring complementary expertise to the review as specified in the Agreement. The experts were supported by a Rapporteur and the NEA Secretariat. All contacts between ROSATOM and the IEF team were organised and managed through the NEA.

The IEF team has the following areas of competence:

- expert knowledge for developing and evaluating cost structures for estimation of decommissioning costs from different European countries;
- expert knowledge in decommissioning of various types of nuclear installations including Russian type reactors;
- expert knowledge for the application of ISDC and for developing cost methodologies for programmatic approaches.

The IEF is organised taking into account the relevant NEA guidelines for international peer reviews (NEA 2005; NEA 2014). The IEF is based on the following reference material provided by ROSATOM:

- The Methodological Guidelines for Estimation of Nuclear Facilities Decommissioning Costs (hereinafter "Classifier" in this report); this is the industry "Classifier" for Decommissioning Activities, which consist of an English summary of a Russian document not provided to the IEF team members. Note: Classifier in this report refers to this Methodological Guidelines document whereas details of the Classifier methodology and its application are referred to as "classifier".
- A presentation, "Methodological guidelines for nuclear facilities decommissioning costs valuation", and a supplementing presentation, "Costing Methodology for Decommissioning Nuclear Facilities in the Russian Federation", given during the working visit.
- Calculation model for one of the NPP unit types, i.e. the VVER-1000.
- The feasibility of rates used in the Classifier of activities/rates for the decommissioning of NPPs.
- The estimation model for decommissioning costs of nuclear facilities in Russia.

These documents have been provided by Russia to the IEF team in English translation.

In addition, the IEF team received supplementary information from ROSATOM in answers to questions and in meetings with staff from ROSATOM during the working visit to Russia in September 2016.

In order to focus on particular parts of the review, the IEF experts initially divided into two groups. One group focused on the details of the ROSATOM Methodology, while the other group focused on its application. Both groups reported back to the full IEF team, and the key findings and observations presented here are those of the IEF team as a whole. This report therefore presents the consensus view of the IEF team.

In reviewing the details of the ROSATOM Methodology, the IEF team considered the overall approach taken and focused on a specific example provided in the Classifier for nuclear reactor decommissioning. It should be noted that the IEF did not consider in detail the application to other types of nuclear facilities.

In reviewing the application of the ROSATOM Methodology, the IEF team considered its applicability to reporting of liabilities for the annual financial statements. In addition, the IEF team also considered its application and its further development for other potential purposes (such as budgeting, decommissioning programme management, etc.). The IEF members did not conduct a detailed evaluation of calculations and individual parameters and values used in the cost estimation for decommissioning in Russia. Rather, the IEF used the specialist knowledge of its members and its collective understanding of international good practice to evaluate the information provided and to make findings and recommendations.

The IEF team has made its best effort to ensure that all information is accurate.

2. Statement to ROSATOM

The ROSATOM Decommissioning Cost Estimation Methodology is generally aligned with the International Structure for Decommissioning Costing (ISDC), and both the methodology and its application reflect current good practices in decommissioning cost estimation.

Based on its review of the ROSATOM Methodology as applied to a nuclear power plant example, the IEF team concludes that the methodology is sufficient and credible as a basis for calculating estimates of the costs of decommissioning nuclear facilities in the Russia for the purposes of fulfilling its financial reporting obligations.

Further experience in application of the ROSATOM Methodology and feedback from its use would be expected to support ongoing development of the ROSATOM Methodology and facilitate its wider use for planning and financing purposes.

3. Observations concerning the ROSATOM Methodology

3.1. Overview of the ROSATOM Methodology

The methodology that ROSATOM developed is similar to the International Structure for Decommissioning Costing (ISDC) in terms of the structure of the Classifier and the cost structure. Nevertheless, it differs from it as:

- The number of the group of activities depends on the type of nuclear facility, which are split into "typical" and "non-typical".
- Costs for management of radioactive wastes produced during operation are calculated separately from decommissioning costs.
- Spent fuel management is also calculated separately from decommissioning costs.

The sources of information for the rates listed in the Classifier of the ROSATOM Methodology are:

- industrial data
- expert analysis
- international practice
- market data

The ROSATOM Methodology has the following features:

- Spent nuclear fuel management, management of radioactive wastes produced during operation and infrastructure development costs are not included in this evaluation.
- For NPPs, the decommissioning costs are calculated for the entire building; for other types of nuclear facilities, non-contaminated buildings and construction are not included.
- Basic data on the facilities to be decommissioned is provided by operators. This basic data is supplemented where necessary by experts' assessments.
- Operators choose the decommissioning strategy, taking note of the proposed duration of stages of decommissioning provided.

The main characteristics of the calculation of the cost of the management of radioactive waste arising from decommissioning are:

- The radioactive waste management scheme is individual for each nuclear facility and the operators provide the data on physical characteristics, radioactive waste management schemes and costs;
- The development of a temporary list of radioactive waste containers for disposal;
- The disposal rates are established by the Ministry of Natural Resources of the Russian government.

3.2. Types of costs and levels of accuracy

The ISDC (see NEA 2012, section 2.2) indicates three types of cost estimates, namely:

1) Order-of-magnitude estimate, without detailed engineering data, where an estimate is prepared using scale-up or -down factors and approximate ratios. This is used at early stages when the overall scope of the project has not been well defined. The level of accuracy expected is -30% to +50%.
2) Budgetary estimate, based on the use of flow sheets, layouts and equipment details, where the scope has been defined but the detailed engineering has not been performed. The level of accuracy expected is -15% to +30%.
3) Definitive estimate, where the details of the project have been prepared and its scope and depth are well defined. Engineering data would include plot plans and elevations, piping and instrumentation diagrams, one-line electrical diagrams and structural drawings. The level of accuracy expected is -5% to +15%.

According to the information received from ROSATOM, the primary purpose of the cost estimation is to report its decommissioning liabilities in the annual financial statements.

Further assessment of the ROSATOM Methodology is aimed at determining if the methodology is "fit for the purpose" and where further improvements might be necessary.

Key finding 3a: The computation model and data used is suitable for preparing a cost estimate for the purpose of the financial reporting.

The ISDC list is a comprehensive list which is applicable for any decommissioning project. Typically, the user of the system selects the items suitable for his/her application. The ISDC system may be used for different types of nuclear facilities.

The type of the costs in the ROSATOM Methodology follows the ISDC structure using a set of seven items with a hierarchy of three levels:

1) Pre-decommissioning activities: this includes mainly paperwork such as strategy work and preparation of licensing material;
2) Dismantling and decontamination activities during preparation for safe enclosure: this includes minor work in a limited area;
3) Dismantling and decontamination activities during safe enclosure: this includes work outside the safe enclosure area;
4) Dismantling and decontamination activities during shutdown: this includes work in all areas of the plant after safe enclosure;
5) Site rehabilitation: this includes removal of conventional waste during the cleaning of the site;
6) Project management, engineering and support: this includes costs for overall management of the decommissioning project, maintenance of the plant and plant adaptation work;
7) Scientific and research work and design and experimental development: this includes costs for updating the decommissioning project documentation and for the development of methods and procedures for characterisation, dismantling, waste management, simulation, visualisation and 3D-modelling.

These groups cover a number of items given in the ISDC principal activities, i.e.:

- 01 Pre-decommissioning actions;
- 02 Facility shutdown activities;
- 03 Additional activities for safe enclosure or entombment;

- 04 Dismantling activities within the controlled area;
- 06 Site infrastructure and operation;
- 07 Conventional dismantling, demolition and site restoration;
- 08 Project management, engineering and support;
- 09 Research and development.

In the ROSATOM Methodology, the ISDC principal activity, "05 Waste processing, storage and disposal", is included in the overall estimation by using a separate calculation model.

According to the ROSATOM Methodology, the ISDC principal activity, "10 Fuel and nuclear material", is not considered as being part of decommissioning and is thus not covered by the estimation.

The ISDC principal activity, "11 Miscellaneous expenditures", is not included in the cost estimation at all.

Similar to the ISDC approach, the ROSATOM Methodology does not include a methodology for risk management. The recalculation of the costs is repeated annually taking into account the work done during the previous year. The Classifiers are updated based on the experience available from the projects, adding, when necessary, a contingency provision in the range of 3% to11 %.

In the ROSATOM Methodology, the group 6, "Project management, engineering and support", includes decommissioning management costs, site operation costs (routine maintenance and adaptations of the plant systems for decommissioning where necessary) and costs for management of contracts (supervision, QA, etc.) in one single item (per period safe enclosure and abandonment).

In the ISDC system, project management and operating organisation costs are normally separated and grouped under, "08 Project management, engineering and support" and "06 Site infrastructure and operation".

Key finding 3b: Separation and regrouping of the management and support costs under item 6 of the ROSATOM Methodology would improve the transparency and visibility of the methodology and facilitate the comparison of the different projects and cost estimate methodologies. The IEF team recommends that overall decommissioning management be considered independently from involvement of contractors in the project (planning, scheduling, quality assurance, etc.). Such a change would also more clearly show the costs associated with decommissioning and site operation.

Key finding 3c: Some rates used in the Classifier result from evaluation of relatively old input data (price information from 1991). This affects the accuracy of the model as present developments in technologies and methods might not be considered appropriately.

Key finding 3d: The investigation of recently developed technologies and methods may be helpful to update the unit prices for some classifiers used in the model and to improve the accuracy of the estimate.

3.3. Estimating approaches

Key findings 3e: The ROSATOM Methodology uses a combination of bottom-up technique and specific analogy technique, which are the first two options in the ISDC system (chapter 2.3). The IEF team considers that this aspect of the ROSATOM Methodology is in line with the one used in the ISDC recommendations.

Key findings 3f: The formulas presented in the reviewed material are clearly presented and easy to understand and follow.

3.4. Cost element definitions

The ROSATOM Methodology includes three different types of estimating approaches:

- estimates based on quantities: mass, volumes, person-years, etc.;
- estimates based on time: organisational costs for own personnel, maintenance works, etc.;
- special items required only once during the decommissioning project: preparation of licensing documents, construction of facilities needed for dismantling of structures, systems or components, etc.

Key findings 3g: All cost categories (labour, expenses, investments and contingencies) are included in the rates. The procedure used in the ROSATOM Methodology simplifies the cost estimation process and gives results which are appropriate for the estimation of an overall budget.

Key findings 3h: To facilitate the application of the ROSATOM Methodology for other purposes such as planning, it would be appropriate to separate the cost categories (labour, expenses, investments and contingencies). This would also make the ROSATOM Methodology more comparable with other cost estimation methodologies, including the ISDC approach, and will increase its auditability and transparency.

3.5. Description of the cost estimating process

The cost estimation process in the ROSATOM Methodology includes several steps, such as the definition of decommissioning strategy, collection of information from plant operators using a questionnaire, determination of typical activities of work to be performed in the decommissioning project and scheduling of the works. The process also includes several verification steps to validate the data.

In the calculation process at first the total of the overnight costs are calculated. Then, in accordance with the decommissioning schedule, the overnight costs are escalated. In the last step, the escalated costs are discounted to provide the present value of the current liability.

Key finding 3i: The cost estimation process of the ROSATOM Methodology corresponds to the ISDC description of the process, as presented in chapter 2.5 of the ISDC. Based on the observations of the IEF team, the ROSATOM Methodology is consistent with current good practices and similar to the methods used in other countries, e.g. in Italy, in Germany.

3.6. Boundary conditions for cost estimation

Boundary conditions are used to describe the decommissioning strategy, decommissioning phases, scope of work and intended end-state for decommissioning and major activities used in calculating the estimate in each instance. The documentation provided to the IEF team determined the boundary conditions of the ROSATOM Methodology at a general level. Nevertheless, according to additional information provided by ROSATOM, more specific boundary conditions are given for each of the different types of nuclear facilities (e.g. NPPs, disposal sites, etc.).

Key findings 3j: It is important to define the boundary conditions and the scope of decommissioning cost estimation precisely. Clear definitions contribute to accuracy and reliability of the ROSATOM Methodology, and facilitate the comparison with other methodologies and cost estimates. The use of clear boundary conditions would also facilitate the process of checking that there are no gaps or overlaps in the estimation of nuclear liabilities.

The areas, where the boundary conditions could be more clearly determined, include:

- the management costs;
- the assumptions concerning the roles of personnel and subcontractors;
- the initial state of the project;
- the final state of the project.

3.7. Cost structure hierarchy

Key findings 3k: The cost structure hierarchy in general corresponds to the hierarchy of the ISDC. The IEF team noted some differences at the third level of the hierarchy in certain areas and recommends that ROSATOM endeavour to maintain consistency with the ISDC, taking into account the specific features of nuclear facility decommissioning in Russia.

Key findings 3l: The IEF team noted from its review of the structure that there were some indications that the list of classifiers used in the ROSATOM Methodology might not be fully complete and/or may contain some misplacements. The IEF team suggests that ROSATOM consider a further review of the completeness and accuracy of the list.

Based on the experience of the IEF team, there are some time-consuming work categories that were not separately presented in the ROSATOM Methodology. Some examples are:

- dismantling of electrical devices/systems in the controlled area CAA1 and CAA2;
- pressuriser location in the free access area (FAA) seems to be incorrect;
- missing equipment for fuel handling, load lifting equipment and other items mentioned in the "feasibility of rates" document.

Including the missing items as separate classifier items would increase the transparency, completeness and accuracy of the ROSATOM Methodology.

The discussion with ROSATOM during the meeting indicated that the classifiers' names do not fully reflect the actual content of the respective item and in some cases the classifier includes more items than described in its heading. However, the use of broad categories or the use of the label "other" means that the IEF team is unable to verify the completeness and accuracy of the list. Accordingly, the IEF team recommends that such a review is undertaken by ROSATOM, with the aim of making the list of items as detailed and specific as possible.

Key finding 3m: The IEF team suggests that a more comprehensive description of the content of the activities be included in the documentation as this may help clarify the issues (works) covered by the individual classifier. In addition, specific classifier numbers could be added to the headlines in the "feasibility of rates" document. This would make the method more transparent and easy to review.

3.8. Approach to uncertainties (contingencies, risk management)

Key finding 3n: Contingencies are included in the rates. The average contingency is based on expert judgement and information available from the suppliers. The values used in the ROSATOM Methodology lie in the range of 3-11% and seem to be reasonable. The approach of using contingency is consistent with the ISDC system.

There is no risk management section in the ROSATOM Methodology, but the user reiterates the calculations annually. This fits well in the use of the methodology for financing documentation purposes. Risk management is also not included in the calculation approach suggested in the ISDC.

Key findings 3o: For future use of the method for other purposes, it would be beneficial to include risk management elements in the method. This might help to more correctly assess works that are not very well known at present time (e.g. decontamination of building structures). The IEF team notes that work on addressing uncertainties in decommissioning cost estimation and building on the existing ISDC approach is currently ongoing in a joint IAEA and NEA project, and that the report containing the new guidance is to be published by the NEA in early 2017.

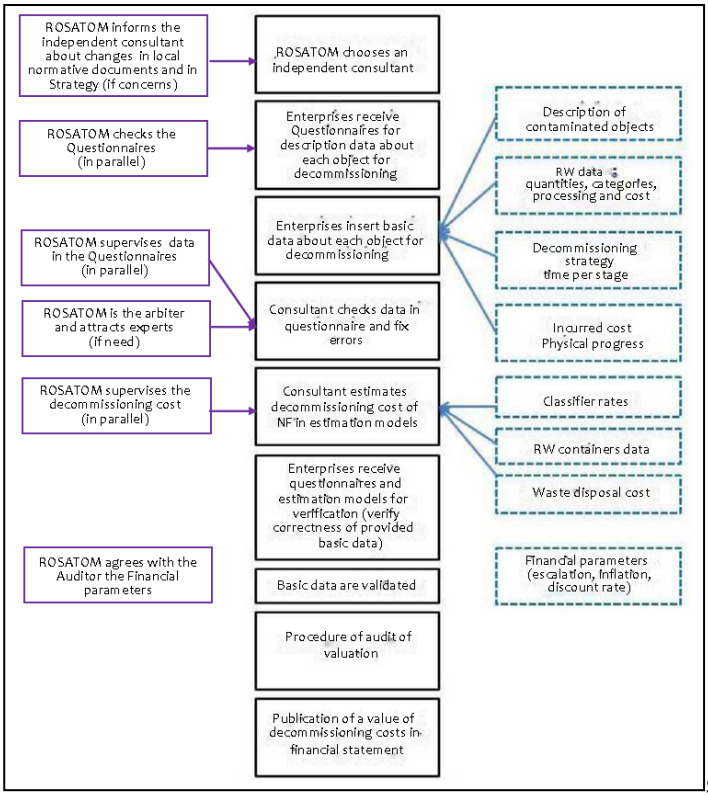
4. Observations concerning the "application of the ROSATOM Methodology"

4.1. The context for the application of the ROSATOM Methodology

The IEF team understands that the ROSATOM Methodology has three aspects:

- Technical (following IAEA guidelines);
- Costs (following the International Structure for Decommissioning Costing [ISDC] recommendations);
- Financial (audited by an auditor of consolidated financial statement [hereinafter – financial auditor)].

The following sections focus on the technical and cost aspects of the procedure. The International Expert Feedback (IEF) team considers that the process generating the input data is an integral part of the methodology as it has a determining impact on the final result. Therefore, the sources of input data and then the methodology application workflow are described as shown in the figure.



Source: ROSATOM

4.2. Inputs to the model

The following inputs for the model were identified (*i.e. the boxes on the right side of the figure*).

Description of the contaminated object

The operators deliver all necessary information about the plant including physical characteristics of the facilities, design documentation, technical data sheets (for the buildings, structures and equipment), explications, data of radiation safety audit, expert assessments, etc.

Decommissioning strategy (concept, duration)

Key finding 4a: There are two proposed strategies for NPP decommissioning in the ROSATOM Methodology and they are consistent with ISDC and current IAEA guidance.

Different decommissioning concepts are presented in the Classifier (Methodological Guidelines) with stages and proposed timescales for different types of facilities. The operator has the possibility to adapt the timescale for each stage of the decommissioning phase to his need or plans. The rationale for its decision to depart from standard values would need to be documented.

Due to the range of the different facilities types and the number of decommissioning objects, this approach is deemed appropriate.

The IEF considered the example provided for an NPP facility and noted that the two cases considered were deferred dismantling and immediate dismantling. The proposed stages are consistent with ISDC and current IAEA guidance (IAEA 2014).

Radioactive waste data

Key finding 4b: The treatment of radioactive waste arising from decommissioning is described in a separate methodology guideline. While the IEF team did not review this separate guideline, it noted that such an approach is compatible with ISDC.

The treatment of radioactive waste is set out in a separate classified methodology.

These costs are calculated on the basis of other regulations/methodologies that are not provided in the documents made available to the IEF team.

The costs for disposal are given by the government for different waste types. The IEF team did not review the costs used.

Incurred cost/physical progress

Key finding 4c: It was noted that information was collected on costs already incurred in ongoing decommissioning projects. This issue was not considered in detail by the IEF team, as it has less impact in the reporting of future financial liabilities. However, clearly, such information would be highly relevant for further developing the ROSATOM Methodology for other purposes.

The operator can deliver information about physical progress and incurred costs. Depending on the purpose of the cost estimation, this information can be useful.

Unit costs (rates in classifier)

Key finding 4d: The definition of the unit costs for the classifier items is documented in a transparent way.

The rates are updated periodically and the source is documented. In case more adequate rates are available, the rates are adopted for the specific case.

Input data for the classifiers' rates comes from different sources' (industry, expert analysis, etc.) delivering information to determine these rates.

The Classifier is revised from time to time in order to update the composition of activities and rates. ROSATOM informed the IEF team that this is currently done on an annual basis.

They have to be approved by the Director for the State Policy in the field of radioactive waste, spent fuel and nuclear facilities decommissioning (see Classifier/Methodological Guidelines, chapter 3, point 5).

The use of a number of different sources of information (i.e. industry data, expert analyses, international practices and market data) is an advantage in developing values for each classifier.

The quality of the data (in terms of the unit cost values given) depends on the source (e.g. recent contractual offers vs. calculated cost estimate) and the list of sources and values is documented in detail.

The value of the rates is determined by the consultant. The underlying reasons for the choice of values and/or the procedure to be followed in determining the values are not documented in the material provided to the IEF team.

Additional information on the verification process of the classifier rates was delivered during the meeting.

Key finding 4e: The credibility of the process would be further improved by introducing an information quality indicator for each classifier item.

The source of the data used to determine the unit cost is very diverse. It includes industry data (cost estimation, feasibility study, detailed project plan, reports on actual costs), expert analysis (e.g. VNIIAES JSC report), international practices and market data. The data might come from a recent experience or be decades old, it might relate to a very similar activity or a vaguely related activity. Some rates are calculated combining several pieces of information using assumptions that cannot always be verified. Some rates are derived from just one source while other are corroborated from several sources.

Consequently, a particular unit cost data can be of a higher or lower quality; in other words, it can be more or less relevant, timely, understandable and reliable. The IEF team suggests that associating an indicator of quality to each unit cost would support the credibility of the final result.

This indicator might be an aggregation of more detailed indicators (like relevance, timeliness, clarity and reliability) or a qualitative grading, possibly using a scale similar to the levels of accuracy proposed in the ISDC for defining cost estimates at project level (see NEA 2012, section 2.2).

The quality indicator could also be used to prioritise the yearly update of the Classifier and to use as input for sensitivity analyses.

Key finding 4f: The IEF team suggests that it could be useful to develop and document a process to help identify suitable rates that meet an appropriate predetermined quality.

A documented procedure to define unit costs would ensure consistency of the methods used to define them across time and through organisational changes.

When considering the use of the decommissioning cost estimates for other purposes than reporting financial liabilities, the required level of accuracy of the estimates should be re-evaluated (see also key finding 4p). As the quality of the individual unit costs may have a determining influence on the global cost estimate, the targeted level of quality for each of them could and should be determined beforehand.

Radioactive waste container cost

A temporary list with possible containers for 2015 was developed. It contains detailed information for each container type. The source of data is the industry.

Financial parameters (inflation, discount rate)

ROSATOM establishes the financial parameters (discount rate and inflation) according to the Classifier, and they are validated by the financial auditor.

4.3. Workflow followed when applying the ROSATOM Methodology

The procedure followed by ROSATOM is illustrated on the left side of the figure.

ROSATOM chooses an independent consultant

Key finding 4g: Currently, the knowledge about the implementation of the ROSATOM Methodology, and in particular the use of the calculation model, resides mostly with the external consultant. The IEF team recognises the value of this during the development phase of the ROSATOM Methodology. The IEF team suggests that ROSATOM considers additional organisational measures to ensure the sustainability of this knowledge, expertise and experience.

The IEF team recognises that this can be achieved in different ways and will depend on the organisational approaches used by ROSATOM. Such measures could include the creation of a unit or functional group in ROSATOM structure where the supervision, control and technical expertise functions related to the cost evaluation methodology would be located. The IEF team is aware that ROSATOM may need further involvement of consultants in implementing the ROSATOM Methodology, but does not express any particular view on the continuing involvement of the consultant or how this role might be defined.

Enterprises receive questionnaires for description data about each object for decommissioning

Enterprises insert basic data about each object for decommissioning

Key finding 4h: There are situations where the consultant provides the operator with support to fill in the questionnaire. The IEF team sees such support as valuable for ensuring consistency and for helping when the resources required are significant considering the operator size.

The operator delivers a questionnaire for transfer into the estimation model with:

- a detailed description of the nuclear facility;
- the decommissioning strategy and the time needed for each stage of the selected strategy;
- the decommissioning activities in physical units for the work done in the specific state;
- information and data on the radioactive waste management and the cost of radioactive waste processing;
- data classified into groups and blocks according to the Classifier and aggregated radioactive waste volume and codes according to the Russian radioactive waste classification.

Physical units of the activities are determined on the basis of the data of physical characteristics of the facilities, design documentation, technical data sheets (for the buildings, structures and equipment), explications, data of radiation safety audit, expert assessments, etc.

The volumes of radioactive waste released from the decommissioning of a nuclear facility are recommended to be determined on the basis of characteristics of the nuclear facility, technologies and peculiarities of proposed work on nuclear facility decommissioning.

Completing the questionnaire for thousands of objects might be a time-consuming task. This should be kept in proportion with the intended use.

Consultant checks data in questionnaire and fixes errors

Key finding 4i: The extensive checks and validation of the data by the consultant increase the quality of the input data and enhance confidence in the overall cost estimate.

Consultant estimates decommissioning cost using estimation models

Key finding 4j: The IEF team is confident that the calculation model will function to produce the estimate as described in the documentation and the presentation delivered.

The procedure of data input is described in the delivered document, "*Description of the estimation model for decommissioning costs determination*". Although the IEF team was unable to fully run the Excel spread sheet due to file conversion problems, the IEF team was able to discuss the operation of the model on this system and see the outputs. The IEF team also thanks ROSATOM for the offer (eventually declined by the IEF team because of time constraints) to show the model on one of the ROSATOM computers.

The cost of the radioactive waste consists of the main groups: preparation packaging, transportation, disposal (rates given by the Ministry of Natural Resources and Environment of Russia).

Key finding 4k: There is an intention to move from the Excel calculation model to a dedicated purpose-built platform. The development of a dedicated calculation tool would be expected to improve the reliability of the estimations. Confidence in the model and its outcome can be enhanced and strengthened by using a quality management system approach.

Enterprise receives questionnaire and estimation model to check correctness of the provided basic data

Key finding 4l: The IEF team appreciates that there is a process lead by ROSATOM to reconcile any differences in opinion between the various parties involved should it occur.

Key finding 4m: The IEF team did not evaluate the reporting of the cost estimate outputs from the methodology as this is not considered an important consideration for the current purpose of the financial reporting of the liabilities. However, it would be useful to develop guidelines on the reporting of the cost estimate, in particular if the ROSATOM Methodology is further developed for other purposes, such as estimates for specific projects. Useful guidance can be found in the ISDC (NEA 2012, section 4.3) and the "Practice" report (NEA 2015).

4.4. Responsibilities

Key finding 4n: The responsibilities between the various entities involved in the process are well defined. The interfaces between the stakeholders are well established. This enhances transparency and confidence in the process.

The IEF team's understanding of the responsibilities of the stakeholders participating in the cost estimation workflow is as follows:

Operator

The operator is a central figure in the process. Based on its knowledge of the facilities under its responsibility, it collects and reports the physical quantities to be decontaminated, dismantled or destroyed; it defines the decommissioning strategy and the consequent list of activities; and it evaluates the quantities, characteristics and treatment path of radioactive waste.

The operator is in charge of updating those data annually and keeping track of the source of all information and of the rationale behind each decision.

Operator company

Subsidiaries of ROSATOM managing a series of similar facilities (e.g. Rosenergoatom, TVEL) are developing procedures to ensure a consistent implementation of the ROSATOM Methodology. They are also assuring a first level of quality control.

Consultant

The consultant selected by ROSATOM to assist in the implementation of the cost estimation methodology has a key role in defining the unit cost. Further in the process, the consultant checks the data provided by the operators.

Depending on the existing procedures this check can be limited (for standard facilities using well defined procedures) or extensive (for specific facilities using ad hoc methods).

ROSATOM Directorate for Public Policy on Radioactive Waste, Spent Nuclear Fuel and Nuclear Decommissioning

This Directorate is responsible for the methodology used in the decommissioning cost estimation process and

- establishes the Classifier (Methodological Guidelines);
- resolves disagreement between operators and the consultant;
- approves the classifiers, including unit cost[2];
- approves the total calculation of the overnight costs.

ROSATOM Accounting Department

Establishes the financial parameters (discount rate and inflation) and approves them with the financial auditor.

Financial Auditor

The financial auditor issues an audit report on the ROSATOM consolidated financial statement as a whole including financial liabilities.

4.5. Quality assurance

The IEF team has not been presented with written quality assurance (QA) procedures covering the cost estimation process. However, the QA activities have been extensively discussed during meetings with the IEF team.

The quality of the output of the cost estimation process depends on the quality of the input data. As noted earlier, in the present situation, the quality of the input data is consistent with the required quality of the output for its present intended use (financial reporting of liabilities). Should ROSATOM decide to use the decommissioning cost estimate for other purposes, the QA process must ensure that all elements of the process are consistent with those new requirements.

ROSATOM indicated that the external consultant has a key role in the data QA process of estimation and reveals basic deviations[3], while all decisions regarding changes and their analysis are taken jointly by the members of the estimation process.

Key finding 4o: The external consultant has a key role in the data QA process, including error correction. The IEF team suggests that ROSATOM consider additional organisational measures to ensure the sustainability of this knowledge, expertise and experience.

Key finding 4p: The IEF team considers that the current QA process is suitable for the current purpose of the cost estimate. Considering the evolving needs of ROSATOM for what concerns the usage of the decommissioning cost estimate, the QA process may need to be further developed to ensure that the quality of the results of the cost estimation process continues to meet evolving requirements.

2. ROSATOM indicated that, at present, this is done for particular projects and ROSATOM is to consider addressing how this might be done more generally during further development of the ROSATOM Methodology.

3. Subsequently, ROSATOM indicated that the consultant can request documentation that explains figures provided or in order to validate changes in the strategy of decommissioning nuclear facilities. ROSATOM indicated that the consultant does not require submission of documentation about the overall dimension of buildings, mass of contaminated equipment and other physical indicators of facilities as this information is provided directly by enterprises. The auditor can ask for documents confirming the information provided from the enterprises during the auditing process, if this is considered necessary.

4.6. References

IAEA (2014), Decommissioning of Facilities, General Safety Requirements – IAEA Safety Standards Series No. GSR Part 6.

NEA (2014), Guide for International Peer Reviews of Decommissioning Cost Studies for Nuclear Facilities, available at: www.oecd-nea.org/rwm/pubs/2014/7190-guide-peer-reviews.pdf

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NEA (2012), International Structure for Decommissioning Costing (ISDC) of Nuclear Installations, available at: www.oecd-nea.org/rwm/reports/2012/ISDC-nuclear-installations.pdf.

NEA (2015), The Practice of Cost Estimation for Decommissioning of Nuclear Facilities, available at: www.oecd-nea.org/rwm/pubs/2015/7237-practice-cost-estimation.pdf.

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