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Comparison among different decommissioning funds methodologies for nuclear installations

Final Report

Country Report Lithuania

on behalf of the European Commission
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Comparison among different decommissioning funds methodologies for nuclear installations

Final Country Report (WP 1/WP 3)

LITHUANIA

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Contents

Summary

There is only one type of nuclear installation in Lithuania – a commercially used nuclear power plant in Ignalina, which consists of two units. First unit started its operation in 1983 and was closed in the end of 2004. The second one commenced the operation in 1987. It will be closed by 2010. The first unit is in the preparation for dismantling (safe maintenance) phase.

The Lithuanian Energy Strategy, revised in 2002, established the exact dates for the final closure of both Ignalina Nuclear Power Plant (INPP) reactors to meet European Union requirements. Decommissioning of such an important facility has a large impact on the energy sector of Lithuania. Currently INPP produces approximately 70% of all power, generated in Lithuania.

The closure of Units 1 and 2 of the Ignalina NPP is the first case when RBMK-1500 nuclear reactors of such capacity are being decommissioned. Thus, there is no direct experience in decommissioning of this type of NPP. Currently, all three phases of the Unit 1 decommissioning are set, providing for a second phase to be finished by 2009 and the third one – by 2030.

Following the Law on the Decommissioning of Unit 1 at the State Enterprise Ignalina Nuclear Power Plant, a new Programme covering decommissioning of already both units was approved in 2005. This programme defines measures that need to be implemented in both units up to year 2010.

Managing of decommissioning activities directly is the responsibility of the operator of INPP – State Enterprise Ignalina Nuclear Power Plant.

According to the cost estimates, made initially in 2001, pure technical costs of decommissioning range from EUR 990 to EUR 1,300. The sum rises up to almost EUR 4 billion if costs for social measures and waste disposal are included. The estimates of indirect costs show that the overall up-front decommissioning of INPP will cost more than LTL 40 billion or approximately EUR 12 billion. These cost cover the direct costs of decommissioning amounting to approx. LTL 14 billion or almost EUR 4 billion (including the costs for social measures and disposal of radioactive waste) and indirect loss of LTL 27 billion or approx. EUR 8 billion which will be felt by all Lithuanian economy and especially social environment. Moreover, there will be a need to modernise existing energy production facilities and construct new ones, improve the reliability of the energy supply and invest into prevention of environmental damage.

Based on two scenarios of labour cost increase in the future, the immediate dismantling of both units would cost respectively EUR 1,24 billion or EUR 2,02 billion (euros of 2002). Management of radioactive waste, according to the latest cost estimates (except of final disposal of used nuclear fuel), make approx. EUR 600 million. The cost for INPP decommissioning immediate dismantling was estimated using deterministic methods. The updated costs and cash flows are taken into account in the Final Decommissioning Plan, which was approved in 2005.

Public has not been involved in the discussions related to cost estimates.

There are presently two different available sources for funding of INPP Decommissioning: The Ignalina International Decommissioning Support Fund (IIDSF); and State Enterprise Ignalina NPP Decommissioning Fund (SEIDF) (further National Fund).

The main source of the National Fund is deductions from the revenue received from the sale of electricity (now 6% after the excise tax). The main sources of the IIDSF are contributions from the EU and other donor countries.

The practice of the implementation of earlier measures of the Decommissioning Programme shows that actual resources required may be higher than predicted.

Up to the beginning of 2006 approx. EUR 600 million was accumulated in the IIDSF, which is to all intents and purposes an EU fund governed by contributors and managed by the European Bank for Reconstruction and Development. The National Fund has accumulated approx. EUR 107 million so far. This in total is approx. 16% of the total sum of decommissioning costs. The State Enterprise Ignalina Nuclear Power Plant Decommissioning Fund is managed independently of the plant operator by governmental authorities.

The Law on the National Decommissioning Fund is not specific enough as regards the spending of the National Fund. The efficient usage of the Fund resources is directly dependable on how much the measures in the decommissioning plan are justifiable, as the clear criteria for selection of projects to be financed from the National Fund are missing.

The major general decommissioning related documents (starting from legislation and finishing with various studies) are made available to the public. The major sources where information on decommissioning activities can be obtained are web-sites.

Regular (annual) reports on the usage of resources of the National Fund are available on the Ministry of Economy web-site.

A few legal regulations and hence perhaps a few reorganisations of the administrative structures would have to be made in order to use the national financial means for decommissioning more purposefully and efficiently.

Furthermore, there is a lack of a clear overview of cost estimation methodologies and assumptions used. It would be recommended, based on the experience of the last years, to make such an overview with updates where necessary. The cost estimates should more precisely and systematically provide costs for separate decommissioning items.

As the main source for the National Decommissioning Fund is share of the revenue from the sales of electricity of INPP, in 2010, when the power plant will cease to produce energy, there may be a lack of national input into decommissioning activities. Therefore other strategies should be prepared how to secure national funding of the decommissioning activities.

1 Introduction and overview

There is one type of nuclear installation in Lithuania – the nuclear power plant in Ignalina, which consists of two units. First unit started its operation in 1983 and was closed in the end of 2004. The second one commenced the operation in 1987. It will be closed by 2010. The first unit is in the preparation for dismantling phase. This report will focus on the analysis of the decommissioning costs of this nuclear power plant. Both units (closed one and currently operating one) will be analysed.

The Government of Lithuania approved the first Lithuania's National Energy Strategy in 1994. Five years later, the Parliament approved the second National Energy Strategy, which was due for a further revision in 2004. However, the resolution of Lithuania to join the European Union and the related pre-accession processes required an approval of a revised Strategy two years earlier than anticipated. This was mainly to establish the exact dates for the final closure of both Ignalina Nuclear Power Plant reactors to meet European Union requirements. Decommissioning of such an important facility has a great influence on the energy sector of Lithuania.

The development of the 2002 Strategy was based on thorough evaluations of the latest European Union directives and recommendations laid down in the EU Green Paper and European Union Energy Charter Treaty. The development of the new Strategy took place at the time of Lithuania's negotiations for its accession to the European Union. Energy issues were dealt with in a separate chapter; the negotiations opened on 11 June 2001 and were successfully closed in exactly a year, on 11 June 2002. The process of the negotiations had an impact on a number of highly important strategic provisions, including the final closure of Ignalina NPP Unit 2 by the end of 2009.

Already the National Energy Strategy approved by the Lithuanian Parliament in 1999 provided that in accordance with the Nuclear Safety Account Grant Agreement Unit 1 of the Ignalina NPP would be closed before 2005, taking into account the conditions of long-term and considerable financial assistance from the European Union and other countries, as well as international financial institutions. Also it provided that Unit 2 of the Ignalina NPP would be closed in 2009, subject to financing sources, the required scope of financing supported by agreements with EU institutions and other donors. It was stated as well that in the event of a failure to ensure the required financing from the EU and other donors, the operation of the Ignalina NPP will be extended taking into account their safe operation period.

The updated 2002 National Energy Strategy states, that taking into consideration the recognition by Member States of the European Union that the decommissioning of the Ignalina NPP will have to continue beyond the current financial perspectives and that this effort represents for Lithuania an exceptional financial burden not commensurate with the size and economic strength of the country, and the declaration that the Member States are, in solidarity with Lithuania, ready to continue to provide adequate additional Community assistance to the decommissioning efforts also after Lithuania's accession to the European Union.

As further recognised in the Energy Strategy, in order to ensure the reliability of electricity supply and integration into the EU internal market, one of necessary measures should be to maintain the existing potential of non-nuclear power plants by gradually adapting them to the requirements of a market economy and by introducing measures for instantaneous capacity balance regulation.

The total installed electricity - generating capacity (nuclear and non-nuclear) exceeds the present domestic needs of Lithuania by three times, and the main source of electricity in the country is the Ignalina NPP, which generates cheaper electricity than thermal power plants using fossil fuel.

The Ignalina NPP was inherited from the former Soviet Union with the low level of safety culture, but much has been done in the last 15 years to improve safety at the Ignalina NPP. Many countries that have considerable experience in the nuclear energy area have provided effective support in improving the safety of the Ignalina NPP to ensure its better compliance with international nuclear safety objectives.

The closure of Units 1 and 2 of the Ignalina NPP is the first case when RBMK-1500 nuclear reactors of such capacity are being decommissioned. Thus, there is no direct experience, and regular updates of various studies and valuations carried out are being and should be performed to ensure safety requirements in the long closure process.

After the closure of the Ignalina NPP, the existing capacities will be sufficient to meet the national demand for a period beyond the year 2010 in all cases of the domestic demand growth in Lithuania, if the Lithuanian Power Plant, an existing thermal -fired power plant of 4 x 300 MW capacity, is maintained and modernised. After the closure of both units of the Ignalina NPP, the Lithuanian Power Plant will become the major source of electricity. All the four units should be prepared for operation before the closure of Unit 2 of the Ignalina NPP. Having modernised the existing thermal power plants, the cheapest electricity generating sources would be combined heat and power plants in the combined heat and power operation mode, and their share of electricity generated (also taking into account the contribution of new CHP plants) in the total electricity balance could increase from approx. 17% of electricity supply to 35-45% of electricity supply demand in 2015-2020. The remaining 65-55% will be supplied from the Lithuanian Power Plant, hydro pumped storage, hydroelectric plants, wind turbines and other sources. A greater contribution of CHP plants would correspond to a scenario of high fuel prices as CHP plants enable to increase the total fuel consumption efficiency. With regard to changes in fossil fuel prices, the construction of new hydro power plants on the Neris cascade and the mid Nemunas may be justifiable.

Undoubtedly, opinions of various stakeholders vary on some essential issues related to the future energy policies, particularly as regards the future of nuclear and hydro energy.

The negative effects of the premature closure of Unit 2 of the Ignalina NPP will, of course, be more abrupt and will have larger impact on the national economy, compared to a later closure. Currently, extensive discussions are being held regarding a possibly new nuclear power plant in Lithuania. However, it is to be hoped that the emotions and professional "patriotism" will not lead to an unjustified preference for one or

another mode of electricity generation. The final decisions should be made by those choosing to invest in one technology or another, after comprehensive economic evaluations of the profitability of alternative investments, and with a thorough evaluation of risk and safety aspects.

There is not yet any clear policy regarding the future of the nuclear energy in Lithuania.

Taking into account global nuclear energy development trends, the latest technologies of reactors and their technical-economic characteristics, a study on the continuity of the use of nuclear energy in Lithuania was prepared by Kaunas Technological University in 2005, covering the justification of nuclear safety and acceptability of nuclear energy, including the construction of new nuclear power plants (reactors). Because of many unclear conditions as regards the Baltic and, more general, European electricity market and possibilities of energy export, precise recommendations were not provided, however, based on known costs for alternative technologies, increase of gas prices forecasts, environmental requirements and assurance of reliability of energy supply, this study showed a slight cost advantage of nuclear power compared to alternative technology. However, since this report is on decommissioning funding and not on power planning for Lithuania, it cannot be analysed here in more detail in how far the assumptions set in this study are realistic ones and take into account all costs of nuclear energy.

The evaluation of all groups of consequences resulting from the closure of Units 1 and 2 of the Ignalina NPP are being regularly updated on the basis of the most recent information. It is acknowledged that while updating such evaluation, the actual costs incurred should be taken into account, as well as a number of dynamic parameters, i.e. parameters related to economic growth, changes and trends in the internal energy market, the reliability of energy supply (including dependence on oil and gas prices in global markets), effects of efficient energy consumption, response to social consequences, the role of the private sector, as well as the complexity and extended duration of the decommissioning process.

There are quite a few legal acts providing background for the decommissioning activities in Lithuania. The major, related to the decommissioning, can be listed:

- Law on Nuclear Energy (14 November 1996)
- Law on the State Enterprise Ignalina Nuclear Power Plant Decommissioning Fund (12 July 2001)
- Governmental Resolution on the Approval of the Rules of the State Enterprise Ignalina Nuclear Power Plant Decommissioning Fund and the Expenditures Connected with the Establishment of such Fund and the Handling of Spent Nuclear Fuel (17 April 2004)
- Governmental Resolution on the Establishment of the State Enterprise Ignalina Nuclear Power Plant Decommissioning Fund's Council (7 February 2005)

- Governmental Resolution on the Approval of the Decommissioning Programme for the State Enterprise Ignalina Nuclear Power Plant's First and Second Units (2 February 2005)
- Governmental Resolution on the Approval of the Plan for the Implementation of the Decommissioning Programme for the State Enterprise Ignalina Nuclear Power Plant's First and Second Units (25 February 2005)
- Framework Agreement between Republic of Lithuania and European Bank for Reconstruction and Development Relating to the Activities of the Ignalina international Decommissioning Support Fund in Lithuania (5 April 2001)
- Final Decommissioning Plan approved by the Minister of Economy (4 July 2005, Order No. 4-259)

To put legal framework on implementation of the National Energy strategy the Parliament of the Republic of Lithuania adopted the Law on the Decommissioning of Unit 1 at the State Enterprise Ignalina Nuclear Power Plant.

Currently, all three phases of the Unit 1 decommissioning are set (see below in chapter 2), providing for a second phase to be finished by 2009 and the third one – by 2030.

Table 1 Overview on nuclear installations in Lithuania

Nuclear facility	Short name	Country	Kind of facility: NPP = nuclear power plant RR = Research reactors Others: please specify	Output: MW_{el} / GWh/a for NPP	Operational period	Operating company	Decomm. started in year	Decomm. stage*	Analysed in this report
Ignalina Nuclear Power Plant, 1 unit	INPP	LT	NPP	1500 MWe	December 1983 – December 31, 2004	State Enterprise Ignalina Nuclear Power Plant	There is no explicit definition of the starting point of decommissioning process, however, 2001, when preliminary decommissioning plan was approved, can be considered as start date.	-2	X
Ignalina Nuclear Power Plant, 2 unit	INPP	LT	NPP	1500 MWe	August 1987 - up to 2010	State Enterprise Ignalina Nuclear Power Plant	Not started	Operating	X

* Decommissioning stages:
Operating: Still in operation; not shut down yet
0 Decommissioning announced
1 Decommissioning to stage 1
2 Decommissioning to stage 2
3 Decommissioning to stage 3
3* Decommissioning to stage 3 without civil engineering
-x Decommissioning in progress towards stage x

Source: Questionnaire (Analysis of the Factors Influencing the selection of Strategies for Decommissioning of Nuclear Facilities) for Lithuania (EC Contract No. TREN/04/NUCL/S07.40075) and interview with Ms. Kristina Marcelien□, Ministry of Economy of Lithuania

2 Decommissioning strategies and costs

2.1 Current and past decommissioning activities

2.1.1 Decommissioning strategy

Following the Law on the Decommissioning of Unit 1 at the State Enterprise Ignalina Nuclear Power Plant the Programme on INPP Unit 1 decommissioning was adopted in February 2001. In 2005, the new programme covering decommissioning of already both units was approved. This programme defines measures, which need to be implemented in both units up to year 2010. Major aims and tasks of this programme are (among others):

- Improve the legal basis and ensure safe operation of services responsible for the decommissioning of the INPP Unit 1;
- Prepare for the dismantling of the Unit 1;
- Install modern techniques for the management and storage of used fuel and analyse opportunities for its disposal;

Each year the Ministry of Economy renews the Implementation Plan of the Ignalina NPP Unit 1 Decommissioning Programme. This plan consists of technical, environmental, social and economical measures. The Plan contains a list of detailed activities, implementation schedule, responsible institutions, cost and financing sources.

The Preliminary Decommissioning Plan, adopted in 1999, included analysis of potential future at that time decommissioning strategies, which were three: immediate, deferred dismantling and entombment. In order to choose the best strategy the Ministry of Economy asked the INPP to prepare an analysis of technical and financial considerations having influence for the selection of a strategy. After extensive discussions, in 2002, the Government of Lithuania, basing its opinion on the need to prevent the country from cumbersome long-term social, economical, financial and environmental consequences and having in mind to use INPP staff in decommissioning activities selected an option of immediate dismantling. This is a continuous process starting after final shutdown of Unit 1 and finishing with the interim/final disposal of all radioactive waste and territory restoration. Different factors have influenced the selection of strategy, in particular the development of the state energy policy, social aspects and nuclear safety aspects, technical characteristics of the power plant, financing, radioactive waste storage and international experience in the field of decommissioning of nuclear power plants.

This strategy is the only strategy, on which the Final Decommissioning Plan is based.

Dismantling will start when the appropriate radioactive waste management facilities (as a minimum landfill disposal site and free release measurement facility) are made available and that specific dismantling authorisations are obtained from the relevant Lithua-

nian authorities. Dismantling will start by non-contaminated or slightly contaminated parts. The more contaminated parts will be dismantled only after the waste management facilities are ready.

Unit 1 was closed at the end of 2004. The decommissioning is at the preparation for dismantling stage. Unit 2 is still operating and is expected to be closed up to 2010.

In 2005 the Programme for the final shutdown and decommissioning of INPP Unit 1 was renewed by measures for the decommissioning activities for the period of 2005-2010. This renewed programme encompasses also the works needed for the preparation of the decommissioning of the Unit 2.

As set in the Final Decommissioning Plan of the Unit 1, three main phases are planned for the decommissioning activities of the Unit 1. Decommissioning of the Unit 2 is not yet detailed. Unit 1 shall be decommissioned in the following phases:

1. 2001-2004: initial stage or shut down of the reactor, at the same time preparing for the decommissioning; for Unit 2 this phase is foreseen up to 2010.

2. 2005-2009: preparation for dismantling. The Unit shall never be operated again and must be put in a safe configuration for de-fuelling. This requires modifications/isolations of systems to occur. Spent nuclear fuel and waste accumulated during operation shall be transferred to new storage facilities. For Unit 2 this phase is planned up to 2015.

   Transportation of partly burned nuclear fuel assemblies from Unit 1 to Unit 2 for re-use in the reactor of Unit 2 will also be preceded.

3. 2010-2030: dismantling and related works. This phase begins in overlapping with the earlier one since the strategy of immediate dismantling has been selected. Dismantled contaminated equipment shall be transferred to special storage facilities. Equipment with low contamination level (equipment of the Turbine Hall) will be dismantled first, this is to occur as soon as monitoring facilities (for Free Release) and Landfill disposal are made available (as planned 2007). Decontamination of buildings shall also be carried out during this phase. From the technical point of view this is the most complicated phase. The Final Decommissioning Plan foresees that the dismantling of the reactor will be performed starting from 2015 with remote control tools.

The remaining buildings should be monitored for residual contamination and can possibly be re-used for industrial purposes. Non re-used buildings will be demolished and INPP territory restored.

“Brown field” for a large part of INPP, as described in the Final Decommissioning Plan, must be achieved by 2030 (total duration of about 26 years after final shut down of Unit 1). But green field of the entire INPP site will however not be reached at that time as storage of spent fuel and radioactive waste at INPP site is expected to last beyond 2050 awaiting for final disposal facilities to be made available; and radioactive waste

disposal facilities located at INPP site (Landfill, bituminised waste vaults) will be operated and have an institutional control period extending beyond 2050.

Managing of decommissioning activities directly is the responsibility of the operator of INPP – State Enterprise Ignalina Nuclear Power Plant that is 100% owned by the State of Lithuania. INPP established a Decommissioning Service, which consists of a fully integrated team of plant staff and consultants.

2.1.2 Decommissioning cost estimates

Calculation of decommissioning costs was made by the State Enterprise INPP, which involved efforts of local and international consultants.

According to the cost estimates, made by the PHARE project in 2001, pure technical costs of decommissioning ranged from EUR 987 million to EUR 1300 million.

Moreover, two scenarios of labour cost increase in the future were used. Based on two scenarios of labour cost increase in the future, the immediate dismantling of both units would cost respectively EUR 1,30 billion (number presented above) or EUR 2,02 billion (euros of 2002). The first number is based on the averaged manpower cost at the Plant of 6 EUR/h. In those conditions the manpower cost amounts to some 25 % of the total decommissioning cost. The second scenario assumes that accession to the EU could drive manpower costs in Lithuania to European values in the long term, according to a progressive increase from the present average rate at INPP up to 40 EUR/h by year 2026. This scenario brings the cost estimate to the mentioned EUR 2019 million and the manpower share to some 54 % of the total.

The cost for INPP decommissioning immediate dismantling was estimated using deterministic methods.

Later updates, performed by local experts, showed that the overall up-front decommissioning of INPP would cost more than LTL 40 billion or approximately EUR 12 billion. These cost cover the direct costs of decommissioning amounting to approx. LTL 14 billion or almost EUR 4 billion (including the disposal of radioactive waste) and indirect loss of LTL 27 billion or approx. EUR 8 billion. Moreover, there will be a need to modernise existing energy production facilities and construct new ones, improve the reliability of the energy provision and invest into prevention of environmental damage.

Initially for the purposes of the Preliminary Decommissioning Plan the decommissioning costs and cash flows were estimated for Immediate Dismantling, Deferred Dismantling and Entombment strategies. An analytical breakdown of activities and a decommissioning database were constituted. CALCOM tool of NIS was used for the calculations.

As informed by the Decommissioning Service of INPP, in a second step, the decommissioning cost and cash flow were re-estimated early 2002 for Immediate Dismantling and Deferred Dismantling. This update took on board mainly:

- The dates for shutdown of the INPP Units 1 and 2 (those dates were unknown when drafting the PDP)
- The waste management routes and associated disposal costs (at the time of the PDP the Landfill disposal for example was not considered)
- The manpower costs possible evolution (as mentioned above)

The updated costs and cash flows are taken into account in the Final decommissioning Plan, approved in 2005.

The allocation of costs for separate activities related to both Unit 1 and Unit 2 decommissioning is provided in Appendix 1, which presents the overall chapter 15 of the Final Decommissioning Plan. Here assumptions used for cost estimates are described as well.

Public has not been involved in the discussions related to cost estimates. Moreover, as argued by the Lithuanian National Audit Office in its audit report of July 19, 2005, the public announcement of the Decommissioning Plan with costs for separate projects may decrease the competition and limit possibilities to use the resources of the National Decommissioning Fund efficiently, as pre-determined cost numbers do not encourage potential project implementers to use cheaper technological alternatives.

As this type of Nuclear Plant is being decommissioned first time, there is no similar experience either for more general decommissioning activities or for cost estimates for this type of decommissioning.

The practice of the implementation of earlier measures of the Decommissioning Programme shows that actual resources required may be higher than predicted. E.g., preliminary assessment of the costs for design and construction of the used fuel depository, made by consultants including ones from EBRD, showed a need of EUR 82 million. However, after contracting the costs needed increased up to EUR 160 million.

Recently, based on the experience of INPP staff and foreign consultants working in INPP, costs of waste management (except of final disposal of waste) were estimated as well. Costs for social measures, as well as costs for long-term final disposal of spent fuel have not been estimated in detail. Just based on the experience of other countries the Decommissioning Unit of the Ministry of Economy, after consultations with specialists of the INPP, came to a conclusion that immediate dismantling costs make approx. 55% and final disposal – 15% of total decommissioning costs. Thus, as provided in the Questionnaire in the project of EC Contract No TREN/04/NUCL/S07.40075), costs were “divided” into the following items:

Table 2: Shares of INPP decommissioning costs as of July 2006

Item	Share	Million EUR
Immediate decommissioning strategy	55%	~2020
Total Waste Management Cost in the decommissioning cost	30%	~1200
Cost for management of waste from decommissioning	7%	280
Cost for interim storage of spent fuel	6%	240
Cost for long-term/final disposal of spent fuel	15%	600
Other costs (landfill, NSR)	2%	80
Cost for Social Measures	10%	~400
Cost for supporting programmes for employees	1%	40
Cost for regional development	5%	200
Other cost relating to social aspects of decommissioning (payoff)	4%	160
Other cost not mentioned above (re-generation of energy supply)	5%	~200
Total direct costs of decommission-ing	**100%**	**~3800**

Source: Questionnaire in the project of EC Contract No TREN/04/NUCL/S07.40075 and recent numbers from tenders for projects on waste related services

2.2 Future decommissioning strategies

As shown above, both Units of INPP are being dealt with together from the legal or costing point of view. Therefore for the costs and strategies related to the Unit 2 see section 2.1. above.

Table 3 Expected total costs of future decommissioning of nuclear installations in Lithuania (in prices of 2004)

Short name of nuclear facility	**Kind of facility:** **NPP = nuclear power plant** **RR = Research reactors** **Others: please specify**	**Total decommissioning costs estimated [Mio. Euro]**	**Estimated costs in relation to construction costs [%]**	**Annuity of estimated decommissioning costs in relation to output over lifetime [ct/kWh for NPP; 4%]**	**Remarks**
INPP Unit 1 and Unit 2	NPP	~ EUR 3800 million including social and waste management costs; immediate dismantling according to the higher labour cost growth strategy EUR 2020 million	N/A		According to the Consultant of this project, the total decommissioning costs entailing higher growth of labour costs is more realistic.

Source: Final Decommissioning Plan and Questionnaire on the Analysis of the Factors Influencing the Selection of Strategies for Decommissioning of Nuclear Facilities (EC Contract NoTREN/04/NUCL/S07.40075) Note: costs were estimated in EUR of 2002, however, having in mind uncertainty of up scaling dismantling costs up to the overall decommissioning costs, and the fact that inflation in Lithuania and in euro zone has not been such that would affect the cost estimates, the same values as in 2002 can be used.

3 Funds and fund management

3.1 Setting aside funds

3.1.1 Sources for decommissioning funding

There are presently three different available sources for funding of INPP Decommissioning, namely:

1. The Ignalina International Decommissioning Support Fund (IIDSF);
2. State Enterprise Ignalina NPP Decommissioning Fund (SEIDF) (further National Fund)
3. EU Programmed Instrument for Ignalina

The National Fund resources are:

- Deductions from the revenue received from the sale of electricity (6% before taxes, just after excise tax); in 2005 it amounted to 0.00085 Eurocent per kWh.
- Charity allowances made by foreign countries, international organisations and financial institutions, legal and natural,
- Benefits from estate sold during the closure programme,
- Fund interest and interest of securities (shares) bought for the Fund assets, and so on.

The first source of the National Fund is the most significant one while others bring only minor amounts. Deductions from the revenue on the sale of electricity are transferred to the National Fund quarterly.

The law to establish the State INPP Decommissioning Fund was adopted in July 2001.

A Framework Agreement between the Republic of Lithuania and the EBRD relating to the activities of the Ignalina International Decommissioning Support Fund in Lithuania was signed on 5 April 2001 in London. The Fund accumulates finances of EU countries and other donors and is administered by the EBRD.

Before that, the Nuclear Safety Account Grant Agreement was signed by the European Bank for Reconstruction and Development, Government of the Republic of Lithuania and Ignalina NPP (in 1994). In the Agreement, the Bank allocated the support of ECU 33 million to Lithuania for nuclear safety improvements at Ignalina NPP and Lithuania undertook not to replace the reactor fuel channels at the end of their lifetime, but to shut down the reactors. The channel lifetime ranges from 15 to 18 years.

In addition, since 2004 the EU provides support for the decommissioning activities through the so-called Programmed Instrument. The implementing institution of this programme is the Central Project Management Agency (CPMA), which has been established by the Ministry of Finance of Republic of Lithuania.

3.1.2 Accumulated funds

Ideally with the start-up of NPP's operation and fixing the price for produced electricity, the expenses for subsequent decommissioning of NPP should be taken into account. Thus, decommissioning funds in such a case would be accumulated during the whole plant operation period; which is the most effective way. However, during the first 10 years of INPP operation the funds for this purpose were not accumulated. Only later, after the increase of electricity price, the funds were started to be accrued. Naturally, these funds are not enough to cover the expenses of decommissioning, though the percentage has been increased since 1992 from 1.3 to 6 percent of the revenue.

The major source of revenue in the National Fund is deductions from the sales of energy. Since the beginning of 1999 the deductions equal 6% of revenue after excise duty. The National Fund, since the beginning of its life, has accumulated approx. LTL 360 million or ~EUR 100 million for decommissioning purposes. The financial means of the National Fund were started to be used for various projects in 2002. As of February 2006, the National Fund had in its account LTL 240 million or almost EUR 70 million.

The following table presents the structure of the revenue of the National Fund during one year:

Table 4: Structure of the National Fund revenue in 2004

Structure of the Fund resources	Amount, thou LTL	%
Deductions from the INPP revenue from the sold energy	39,952	84
Investments into state securities	6,879	14,4
Interest for deposits	888	1,9
Total	**47,719**	**100,0**

Source: National Audit Office Audit Report "Evaluation of the Resource Usage of the Ignalina Nuclear Power Plant Decommissioning Fund", Vilnius, 2005 (in Lith.)

The following table presents the National Fund's revenue and spending comparison.

Table 5: INPP Decommissioning Fund Revenue and Spending in 2004-2005

Year	Revenue, thou LTL	Spending, thou LTL	Difference (surplus + / deficit -), thou LTL
2004	47,733	38,834	+ 8,899
2005	48,320	72,867*	- 24,547

Source: National Audit Office Audit Report "Evaluation of the Resource Usage of the Ignalina Nuclear Power Plant Decommissioning Fund", Vilnius, 2005 (in Lith.) and special inquiry in the Ministry of Economy, * -preliminary data

After 2009, when INPP will be finally shut down, the income source of the National Fund will not be available any more.

International Fund mainly finances INPP decommissioning technical projects.

As of the beginning of 2006, approximately EUR 420 million were accumulated in the International INPP Decommissioning Fund.

Table 6: Contributions of various donors to the IIDSF (status of July 2004 as per contribution agreements)

·	**Country**	**million EUR**
1	Ireland	0.50
2	Austria	1.50
3	Belgium	1.636
4	Denmark	2.686
5	European Union (with the sum contributed in 2004)	206.5
6	Finland	1.50
7	France	1.50
8	Germany	6.50
9	Luxembourg	1.50
10	Netherlands	1.50
11	Norway	1.50
12	Poland	1.50
13	Sweden	5.895
14	Switzerland	1.909
15	United Kingdom	1.5
16	Spain	1.5
	Total	239.126
	Interest	4.37
	Total in the IINPPSF in 2004	**~245,00**

Source: web-site of the Ministry of Economy

Including amounts for 2005 and 2006 of which EUR 19 million is still subject to formal Commission decision, Lithuania has so far received a total of EUR 529 million for the support of Ignalina NPP decommissioning from the European Commission. Of this,

approximately 80% is at present scheduled to go through the EBRD in a continuation of past practice, with the remainder being managed in a PHARE-type approach.

The Ignalina Protocol foresees the 'seamless' continuation of 'adequate' EU assistance into future financial perspectives. A proposal for a Regulation was adopted in October 2004 by the Commission, which sets out the implementation of support to the decommissioning of Ignalina. While the Regulation initially foresaw a continuation of the current levels of EU assistance as that in the Ignalina Protocol i.e. of the order of EUR 100 million per year, the European Council conclusions from December 2005 agreed an increase in funding to EUR 865 million during the next financial perspective (of the order of EUR 120 million per year in real terms).

In compliance with the law the INPP Decommissioning Fund resources and the resources of the International Decommissioning Support Fund are allocated to finance and (or) partial finance the following activities: technical and public decommissioning projects, handling, disposal and long-term storage of radioactive waste including spent nuclear fuel of Ignalina Nuclear Power Plant, compensation of nuclear damage.

Grants provided by the International Fund should be complemented by Lithuanian resources that can be in kind, cash, from the National Fund or any other form in all stages of project implementation.

The National Fund resources to finance the activities included into the Ignalina Unit Decommissioning Programme are allocated to comply with the Fund Annual Cost Estimate approved by the Parliament of Lithuania. The Fund resources cannot be allocated for any other objectives except for the objectives specified in the above law.

Until May 2006, out of mentioned EUR 3.7 billion total decommissioning costs and more than EUR 2 billion needed for the immediate dismantling, decontamination and demolition purposes, Lithuania has accumulated only approx. EUR 600 million (in the International Fund, National Fund and the special Ignalina EU programme) or 16% of total decommissioning costs and 30% of dismantling costs respectively.

3.2 Management of funds

The State Enterprise Ignalina Nuclear Power Plant Decommissioning Fund is managed independently of the plant operator by governmental authorities in the National Fund – Council of the Fund. The Ignalina International Decommissioning Support Fund (IIDSF) is managed by the European Bank for Reconstruction and Development. The IIDSF was set by the European Community together with ten European countries in 2001 at the EBRD.

The members of the administrator of the National Fund – Council of the Fund - are appointed by the Lithuanian Government. Members, according to the Law on Decommissioning, are representatives of state, municipal and scientific institutions and INPP. The chairman of the Board is the Minister of Economy of Lithuania. Board members are not paid for their job in the Board, therefore their role is a bit peculiar: in order to fulfil func-

tions of the Board, it would need to collect, treat and analyse a big amount of information, which is very difficult to do working on public grounds. Therefore the reliability on the Ministry of Economy, which has a special unit for the decommissioning activities, is very high. On the other hand, statute of the National Fund does not clearly indicate functions of the INPP Decommissioning Unit of the Ministry of Economy in terms of administering the National Fund resources. Moreover, the INPP Decommissioning Unit in the Ministry of Economy does not have resources for implementing tasks related to the administering of the National Fund.

The Ministry of Finance is allowed to utilize the free resources of the Fund and procure securities (shares) with their later return to the Fund. However, the law is not specific enough as regards the spending of the National Fund. The efficient usage of the Fund resources is directly dependable on how much the measures in the decommissioning plan are justifiable, as the clear criteria for selection of projects to be financed from the National Fund are missing.

As the National Audit Office in its audit found out, because of the absence of precise criteria for the selection of the projects, as indicated in the audit report of the Lithuanian National Audit Office of July 19, 2005, during 2002 – 2004 approximately LTL 20 million or EUR 6 million were used for projects not directly related to the decommissioning of the INPP.

The control of the financial means of the National Fund is designated to the National Audit Office, which, according to its statue, carries out the external state audit. The internal control of the efficient use of funds is to be performed by relevant services of the fund receivers, i.e. companies and/or institutions, implementing decommissioning projects. As the National Fund is not legal public entity, as well as not an entity founded by the Ministry of Economy, it is not a subject of either the implementation of the Lithuanian Law on the Internal Control and Audit or internal control of the Ministry of Economy. Therefore a need to legally establish the internal control and audit system for the National Fund is identified as a priority task by the National Audit Office.

Because of bureaucratic reasons (clarification of exact functions between the Ministry of Finance and Ministry of Economy) the investment policy of the National Fund was started only at the end of 2003, though the possibility to do that appeared already in 2001, when the Minister of Finance adopted Rules on Investing Temporarily Free State Resources. Since the start of investment policy up to the beginning of 2005 almost LTL 7 million of interest payments from state securities were received to the National Fund and that amounts to more than 14% of the Fund revenue in 2004. The interest received from deposits made up almost LTL 900 thou or EUR 260 thou in 2004. However, if the possibility to invest into state securities was used since such a possibility appeared, additional interest of about LTL 8 million would have been gained.

Such deficiencies are limiting efficient usage of the National Fund resources.

Very recently (April 26, 2006) the Government of Lithuania approved changes in the Law on the State Enterprise Ignalina Nuclear Power Plant Decommissioning Fund, which will come to force in 2007. The changes are related to the improvement of the

management, usage and control of the Fund resources. It is defined that the annual budget and the report of the use of the Fund resources will be approved by the Parliament. The Council of the Fund will maintain advisory functions while decision-making and responsibility for the provision of the Fund resources will belong to the manager of the Fund – Ministry of Economy. Moreover, the Government will appoint the Administrator of the Fund. The Ministry of Finance maintains its current role as the holder of the National Fund, which assures correct distribution of the Fund's resources and is responsible for the investing of temporarily free Fund's resources into various markets.

3.3 Special cases: Fall-back option and transfer of ownership

Both Ignalina NPP units are shut down early, therefore the above description of the situation is valid for this specific case.

Table 7 Base for decommissioning funds required

Short name of nuclear facility	**Kind of facility:** **NPP = nuclear power plant** **RR = Research reactors** **Others: please specify**	**Please check if decommissioning funds are based on overnight / undiscounted decommissioning costs**	**Please check if decommissioning funds are based on net present value / discounted decommissioning costs**	**Discount rate used for discounting, if any**	**Reference date used for discounting**	**Remarks**
INPP Unit 1 and Unit 2	NPP	Overnight costs		3% (when estimating costs for choosing the dismantling strategy)	See column for Remarks	Consultants estimating the cost, stated that due to the many uncertainties about the discount rate used over long periods (more than 30 years), experts generally recommend to use two sets of discount rates: • First set covering time scale up to 30 years: net discount rates are then typically in the range 3-5 % • Second set applicable to the period beyond 30 years: net discount rate of 2% is typical The time scale of INPP decommissioning (Immediate Dismantling) being of 25 – 30 years, a net discount rate of 3% is selected

Source: Final Decommissioning Plan, chapter 15 on decommissioning costs and funding

Table 8 Decommissioning funds accumulated in relation to expected total costs of future decommissioning of nuclear installations in Lithuania (in prices of 2004)

Short name of nuclear facility	**Kind of facility:** **NPP = nuclear power plant** **RR = Research reactors** **Others: please specify**	**Total decommissioning costs estimated [Mio. Euro]**	**Provisions accumulated by 31-12-2004 [Mio. Euro]**	**Provisions accumulated in relation to expected costs [%]**	**Years of operation until 31-12-2004 in relation to total expected lifetime [%]**	**Remarks**
INPP Unit 1 and Unit 2	NPP	~ EUR 3700 million ~ EUR 2020 million for immediate dismantling strategy (see also Table 3) and EUR 600 million for waste management (except of final disposal)	By 2006: EUR 560 million from all sources	30% of immediate strategy costs (see also Table 3) 16% of overall decommissioning costs	Unit 1 – 100% (premature closure at 31 12 2004) Unit 2 – 74% (expected premature closure at the end of 2009)	

Source: Final Decommissioning Plan, chapter 15; National Audit Office Report, 2005

Table 9 Management of decommissioning funds in Lithuania

Short name of nuclear facility	**Kind of facility:** **NPP = nuclear power plant** **RR = Research reactors** **Others: please specify**	**Provisions accumulated by 31-12-2004 [Mio. Euro]**	**… of which has been accumulated within the own assets of the operator of the facility or its mother company [Mio. Euro]**	**… of which has been accumulated by the operator of the facility or its mother company within a separated account / segregated fund [Mio. Euro]**	**… of which has been accumulated in an external fund under public control [Mio. Euro]**	**… of which has been accumulated in an external fund under mixed private-public control [Mio. Euro]**	**Share of funds the operator of the facility can access for other activities until the funds are needed for their original decommissioning purpose [%]**	**Remarks**
INPP Unit 1 and Unit 2	NPP	By 2006 EUR 560 million from all sources including commitments		National Fund - ~ EUR 107 million	~ EUR 470 million in the International Ignalina Decommissioning Support Fund		Legally 0%, but practically because of the absence of clear criteria for selection of projects there may be cases when accumulated national funds are used not for direct decommissioning purposes.	

Source: National Audit Office Report and consultant's calculations

Table 10 Investment of decommissioning funds until they are used for their original purpose

Short name of nuclear facility	**Kind of facility:** **NPP = nuclear power plant** **RR = Research reactors** **Others: please specify**	**Provisions accumulated by 31-12-2004 [Mio. Euro]**	**… of which have been invested in secure state bonds [Mio. Euro]**	**… of which have been invested in other assets with fixed interest rates [Mio. Euro]**	**… of which have been lent to associated or joined companies or to third parties [Mio. Euro]**	**… of which have been invested in other means (shares, mergers & acquisitions, etc.) [Mio. Euro]**	**Interest on invested financial means from decommissioning funds in 2004 [%]**	**Interest on invested financial means from decommissioning funds in period 2000-2004 [%]**	**Remarks**
INPP Unit 1 and Unit 2	NPP	By 2006: EUR 560 million from all sources including commitments, of which approximately EUR 170* have been already used for decommissioning expenditures by the beginning of 2006.	In 2004 – LTL 6.9 million or EUR 2 million					LTL 7.8 million or EUR 2.25 million up to 2006	

Source: National Audit Office Report, 2005; * - assumption that EUR 25 million, spent from the National Fund, make 15% of overall spending.

4 Transparency of the funding schemes to the public

The major general decommissioning related documents (starting from legislation and finishing with various studies) are made available to the public. The information centre in INPP was established in 1995.

The major sources where information on decommissioning activities can be obtained are web-sites. Web-sites of the Ministry of Economy and of the Ignalina Nuclear Power Plant are suggesting quite a lot of material regarding the decommissioning activities. However, some information there is outdated. Moreover, the cost estimations and the Final Decommissioning Plan are the items, not provided for the general public view.

Responsibilities and liabilities are not too precisely identified for the major stakeholders themselves, therefore it is hardly believable that they may be entirely understandable for the public. Nevertheless, good efforts are made by the Ministry of Economy to present schemes of organisation of decommissioning funding activities.

Regular (annual) reports on the usage of resources of the National Fund are available on the Ministry of Economy web-site.

Public is mostly involved in the decommissioning activities through the public hearings required by the Environmental Impact Assessment legislation. Moreover, according to the Law on the Provision of Information to the Public, each citizen of Lithuania has a right to obtain relevant information.

Public participation in the decision process on decommissioning funding is not present. Moreover, as already mentioned in the chapter above, it is considered by the National audit Office that the public announcement of the Decommissioning Plan with costs for separate projects may decrease the competition and limit possibilities to use the resources of the National Decommissioning Fund efficiently, as pre-determined cost numbers do not encourage search for cheaper technologies.

5 Stakeholder analysis

Managing of decommissioning activities directly is the responsibility of the operator of INPP – State Enterprise Ignalina Nuclear Power Plant. INPP established a Decommissioning Service, which consists of a fully integrated team of plant staff and consultants. Other stakeholders related to the managing of decommissioning activities in Lithuania are:

- Ministry of Economy of the Republic of Lithuania (Nuclear Energy and Radioactive Waste Management Department and its two units: INPP Decommissioning Division and Nuclear Energy Division)
- State Enterprise Ignalina Nuclear Power Plant
- Ministry of Finance of the Republic of Lithuania
- Ignalina Nuclear Power Plant Region, created on purpose and related to the decommissioning activities
- Visaginas municipality (where the NPP is located)
- Ignalina district municipality
- Zarasai municipality (municipality of the Ignalina NPP Region)
- Utena county administration
- State Nuclear Power Safety Inspectorate (VATESI)
- State Enterprise Radioactive Waste Management Agency (RATA) (established to implement the management and final disposal of all transferred to it radioactive waste, generated by the INNPP during the operation and decommissioning process, and radioactive waste from small producers (hospitals, industry, research institutions etc)
- Radiation Protection Centre (the institution which co-ordinates the activities of executive and other bodies of public administration and local government in the field of radiation protection, exercising state supervision and control of radiation protection, monitoring and expert examination of public exposure)
- Lithuanian Energy Institute
- International Atomic Energy Agency
- Nuclear Energy Agency (OECD)
- European Bank for Reconstruction and Development
- European Commission
- The Lithuanian Green Movement

The founder of the National Fund is the Government of the Republic of Lithuania, the administrator is the Council of the Fund, the distributor is the Ministry of Economy and the holder is the Ministry of Finance. Ministry of Finance assures correct distribution of the Fund's resources. Moreover, it is responsible for the investing of temporarily free Fund's resources into various markets. Ministry of Economy manages the Fund from the "professional content" point of view.

The financiers from EU countries and other donors are accumulated in the Ignalina International Decommissioning Support Fund, administered by the European Bank of Reconstruction and Development.

The implementing institution of the EU Programmed Instrument is the Central Project Management Agency (CPMA), which has been established by the Ministry of Finance of Republic of Lithuania. The CPMA is generally responsible for the efficient management of sovereign loans, and funds from the EU and other international institutions and donors to Lithuania. In addition, the agency is responsible for EU PHARE projects, the provisions of loans to governmental, public sector institutions and for domestic use, and assists with such policies as housing, infrastructure development, and energy.

All major stakeholders acknowledge the need to improve legal environment and bureaucratic procedures to assure the most effective work of all related institutions. As mentioned in the report, recently amendments to the Law on the State Enterprise Ignalina Nuclear Power Plant Decommissioning Fund were approved by the Government, which will come in to force in 2007. The changes are related to the improvement of the management, usage and control of the National Fund resources. The Council of the Fund will maintain advisory functions while decision-making and responsibility for the provision of the Fund resources will belong to the manager of the Fund – Ministry of Economy. Moreover, the Government will appoint the Administrator of the Fund.

It seems that currently functions related to the decommissioning (and especially funding of decommissioning) are disbursed among too many parties without having resources for fulfilling the decommissioning related tasks. There is thinking that concentration of power and functions in one institution (e.g. Agency under the Ministry of Economy) may help in improving the decommissioning funding activities. Moreover, the National Fund accumulation strategy should also be changed, as Unit 2 will cease its operation and the main revenue source of the Fund will not be available any more.

Green Movement of Lithuania, which unites major environmental NGOs, does not, however, think that the creation of a separate agency may solve existing deficiencies of the national and international decommissioning resource spending. Criteria for the decommissioning projects selection should be, according to the representatives of the Green Movement, much more elaborated. The latter concerns spending of not only national, but also international funds, accumulated for the INPP decommissioning. In addition, much more effective control and audit system related to the decommissioning activities needs to be set up. NGOs also claim that transparency related to the information provision should be increased as well.

As stated by the INPP Decommissioning Service, the EU Programmed Instrument for Ignalina still causes many bureaucratic problems. Projects, financed by this source, were started without an appropriate preparation and the financial mechanism is not yet finally tuned. Therefore the INPP Decommissioning Service experiences many difficulties, starting from development of application forms, procurement, and finishing with reporting. In general, all instruments have their own different rules of administration, which make the co-ordination of decommissioning projects quite complicated.

6 Conclusions and recommendations

Small time input in the project does not allow analysing all decommissioning funding schemes and regulations in detail. Nevertheless, based on the references studied and discussions with various stakeholders the following general conclusions and recommendations can be drawn up:

- Early decommissioning of both units of INPP has a huge impact on the Lithuanian energy sector.
- Decommissioning costs are estimated for the immediate dismantling strategy and waste management. Costs for social measures and final disposal of waste component are only “guesstimated” based on experiences of decommissioning activities in other countries and theoretical calculations so far. There are two scenarios developed reflecting different growth of labour costs. Scenario 2, reflecting higher labour cost trend is more realistic. In such a case, the total costs for immediate dismantling would amount to EUR 2.02 billion. Costs for waste management are estimated at EUR 1.2 billion. The overall amount of funds needed add up to almost EUR 4 billion.
- There are three major sources of decommissioning funding: National INPP Decommissioning Fund, International INPP Decommissioning Support Fund and EU Programmed Instrument for Ignalina. The financial means accumulated in the National Fund make approximately 20% and in the International Fund - 75% of all accumulated approx. EUR 600 million sums for decommissioning. The financial means accumulated so far cover only 16% of the expected total costs of dismantling, decontamination, demolition, waste management, final disposal of the INPP units and social measures.
- The evaluation of all consequences resulting from the closure of Units 1 and 2 of the Ignalina NPP are being regularly updated on the basis of the most recent information. Cost estimates were first time made in 2001 and then updated by foreign and local consultants. However, there is a lack of a clear overview of cost estimation methodologies and assumptions used. It would be recommended, based on the experience of the last years, to make such an overview with updates where necessary. The cost estimates should more precisely and systematically provide costs for separate decommissioning items. Costs for the waste management and implementation of social measures should be additionally estimated in detail.
- Some stakeholders recognise difficulties and problems related to the efficient use of the accumulated decommissioning funds. The main reason is insufficient legislation, providing rules for the administration and management of National Fund’s resources. Therefore a few regulations and hence perhaps a few reorganisations of the administrative structures are to be made in order the national financial means for decommissioning are used purposefully and efficiently and

the control and audit system, as well as transparency of information is improved.

- As the main source for the National Decommissioning Fund is share of the revenue from the sales of electricity of INPP, in 2010, when the power plant will cease to produce energy and since the amounts collected so far and expected to be collected by 2010 will by far not be sufficient, there may be a lack of national provisions for decommissioning. Therefore other strategies should be prepared how to secure funding of the decommissioning activities and not leave this as a burden to future generations.
- EU financing has been the main source for decommissioning so far and is expected to remain so in the future.
- Financing mechanism of the EU Programmed Instrument for Ignalina needs to be tuned and possibly co-ordinated with the financing rules of other decommissioning sources to avoid current problems experienced by the INPP decommissioning service.

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Annex

Final Decommissioning Plan. Chapter 15 – Decommissioning Costs and Funding, A.1/ED/B4/0004.

Final Decommissioning Plan

Chapter 15 – Decommissioning Costs and Funding

A1.1/ED/B4/0004

Issue 06

Table of Contents - Chapter 15

List of Tables

List of Figures

15 Decommissioning Costs and Funding

15.1 Costs of the INPP Decommissioning

15.1.1 General

The objectives of a decommissioning cost estimation is to indicate the cost required to complete a decommissioning project, to determine yearly budgets covering the expenditures and to allow further definition of the funding mechanisms. The decommissioning costs are estimated to make sure that sufficient funding is or will be available for the completion of the decommissioning project. The aim is to optimize the dismantling sequence and timing thus minimizing the total decommissioning costs.

The first step in preparing a decommissioning cost estimate is to gather all the as built drawings, construction and exploitation records. This information allows to set-up a detailed physical inventory of the materials to be decommissioned. This inventory can then be completed by a radiological inventory based on the recorded events, the activation and a mapping of the contamination.

The second step concerns the definition of the boundary conditions of the Decommissioning Project (e.g. free release limits and discharge criteria for gaseous and liquid effluents, final objectives of the Decommissioning Project (e.g. green field or restricted reuse), availability of disposal sites for the various categories of produced waste).

The third step is to select the main decommissioning strategy and to define the waste management strategy allowing optimize the decommissioning project in terms of radiological industrial safety and in cost.

The fourth step (but mainly applicable when making a final cost estimate, i.e. just before starting the operations) consist in the set-up of a planning detailed into work packages, tasks and activities and taking into account the physical and radiological inventory.

This process gives as result the overall project duration, the critical path and the yearly detailed budgets in constant money value.

15.1.2 Methodology for decommissioning cost evaluation

The structure of decommissioning costs is similar to the structure of construction project costs rather to the operating costs of facility, because of the possible need to design, engineer, procure and erect specialized and dedicated equipment. For calculation methodology four basic elements is necessary:

1. Cost structure;
2. Mass inventory;
3. Detailed decommissioning activities;
4. Time schedule.

Cost structure

The basic cost structure elements include labour, materials, equipment and services. One approach to estimate costs is to divide them into four categories:

1. Cost needed for detailed studies;
2. Work volume (activity) dependent costs;
3. Time dependent costs;
4. Specific costs.

Detailed studies are recommended for the cost evaluation of work packages requiring large engineering studies, preparation works and/or the use of special decommissioning techniques.

Work volume dependent costs are associated with dismantling, decontamination, waste packaging, transport and disposal of components. These costs can be estimated using the unit costs methodology. Unit costs or ratios are applied essentially to the mass or the surface of structure, equipment or materials. It is for example the case of evaluation of physical dismantling operations (ratios in Lt/m, Lt/m^2, Lt/m^3, Lt/kg, etc.). To improve the accuracy of this method, a detailed list of unit costs can be set up to take into account categories and sub-categories to witch the equipment and/or material belongs.

Time dependent costs are associated with on –site management, administration, routine maintenance, safety, security, insurances, taxes and fees to Authorities.

Specific costs independent from quantities and duration are the costs for investments (i.e. decommissioning tools, dismantling and decontamination workshops, radiological survey, etc.), R&D, training of personnel, fees for licensing process, contingencies and etc.

Generally a decommissioning cost estimate is a mix of the listed 4 cost types. The costs are evaluated in constant money (overnight costs). The advantage of having overnight costs and a standardized list of cost items is that comparisons and benchmark are possible. The inflation rate will be accounted only afterwards, also for the funding mechanism definition.

Each from listed cost types is made up of 6 components, namely:

- Labour costs (including the workers salary, the allowances and the direct overhead costs);
- Services (e.g. cost of work subcontracted outside of the project);
- Expenses (consumables for decommissioning tools, protective clothes, electricity, heating, telephone, water supplies and etc.);
- Investment costs (under the form of a capital or capital rental or hiring costs in the case of unit cost methodology);
- Secondary waste covering the waste produced by a decommissioning technique;
- Contingency (cost to cover incomplete design or documentation, modifications in the legal framework, changes in the market condition, tools / equipment breakdown, late delivery of supplies / equipment and etc.).

The cost of a specific decommissioning task/component is given by:

$$C_{task/component}=C_{Labour}+C_{Services}+C_{Expenses}+C_{Investment}+C_{Sec.Waste}+C_{Contingency}$$

With:

$$C_{Labour}=T_N\ \delta\ HR_{OT}\ (1+OC)/\eta$$

Where:

- T_N is the duration of the work in normal conditions;
- δ is a coefficient (generally >1) accounting for the difficulty of the work conditions (e.g. working with protective clothes, use of ladder or scaffolding);
- HR_{OT} is a hourly rate of the specific workers team
- OC is the overhead cost;
- η is the ratio between the effective working hours and the total working hours. This ratio accounts for the time required to met the formalities for enering/leaving the controlled area.

Examples of productivity factors (in fact - T_N), which can be adopted (they were used in PDP) is given below:

Table 15.1 Examples of productivity factors

Work Type	Specification	Productivity Factor Man-hour/kg
Dismantling contaminated components	Removal of insulation	0,160 - 0,640
	Big components	0,015 - 0,065
	Small components	0,015 - 0,075
	Cables and cable-trays	0,018 - 0,096
	Ventilation channels and equipment	0,080 - 0,240
	Removal of building structures	0,00032
	Collection and removal of miscellaneous material	0,100 - 0,150
Decontamination	Single pieces in a pool	0,010 - 0,200
	Systems in-situ	0,0033 - 0,01
	Building surfaces	0,060 - 0,250
	Transport container	2 - 6 (Man-hour/container)
Conditioning and packaging	Low active solid waste in a drum	0,005 - 0,023
	Low active solid waste in a container	0,001 - 0,010
	Super compaction	0,150 - 0,250
	Toxic waste	0,010 - 0,025
	Combustible material	0,001 - 0,010
	Non-combustible material	0,001 - 0,010
Treatment	LLW liquid waste	0,001 - 0,150
	Spent resins	0,002 - 0,004
Release measurement	Building surfaces	0,03
	Dismantled components	0,00015

$C_{Services}=T_N \times \delta \times HR_S$ (in case of time dependent cost)
$C_{Services}=Q \times UC_Q$ (in case of volume dependent cost)

Where:

HR_S is a hourly rate of the specific service;
Q is the quantity;
UC_Q is the unit cost for a specific task.

The other costs are given by:

$$C_i = Q\ UC_i$$

Where:

UC_i is the "all-in" unit cost for expenses, capital rental or hiring cost or secondary waste.

Table 15.2 Examples for Expenses (consumables) cost factors

Consumables Type	Consumables	Cost Factor	
Cutting tools	Tools, tool equipment	0,75	EURO/Man-hour
Contamination protection	Plastic foils	1	EURO/Man-hour
	Protection Clothes	0,15	EURO/Man-hour
Internal transport	Palettes	250	EURO/Piece
	Drum 200 l	260	EURO/Piece
	Drum 400 l	375	EURO/Piece
Miscellaneous	Water	0,05	EURO/m³
	Electrical energy	0,04	EURO/kWh

Table 15.3 Examples for investment cost

Equipment Type	Equipment	Cost Values
Cutting tools	Plasma cutting facility	25.000 EURO
	Autogenous cutting facility	2.000 EURO
	Stationary saw	6.000 EURO
	Handsaw, drilling machine, grinder	500 EURO
	Hydraulic scissors	1.000 EURO
	Rope saw facility	25.000 EURO
	Self driving pipe saw	6.000 EURO
	Mobile air filtering system	9.000 EURO
Remote controlled handling system	Electro master slave manipulator	1.000.000 EURO
Decontamination	Decontamination pools with H_2 recombination	800.000 EURO
	Liquid waste treatment	400.000 EURO
	Waste collection cask	200 EURO
	Transport vehicle for drums	2.000 EURO

Also for the contingency cost a formula can be provided. The formula is a percentage of task cost (labour plus expenses costs) depending on the task/activity. An example is given below:

Table 15.4 Contingency rates according activity category

Activity Category	Contingency %
Engineering	15
Utility and DOC costs	15
Decontamination	50
Contaminated component removal	25
Contaminated concrete removal	25
Circ. Pump removal	25
Conventional radwaste packing	10
Conventional radwaste shipping	15
Conventional radwaste burial	25
Clean component removal	15
Supplies/consumables	25

The choice of a contingency rate depends on the knowledge of nuclear facility, the decommissioning techniques and the expected evolution of the boundary conditions.

To allow a more easily comparison between cost estimates, IAEA proposed a "standardized list of items for costing purposes" [53] allowing facilitate the comparison between decommissioning projects. This list proposed eleven cost groups:

1. Pre-decommissioning actions;
2. Facility shutdown activities;
3. Procurement of general equipment and material;
4. Dismantling activities;
5. Waste management and disposal;
6. Security, surveillance and maintenance;
7. Site cleanup and landscaping;
8. Project management, engineering and site support;
9. Research and development;
10. Fuel;
11. Other costs.

The list is then further broken down into tasks and subtasks. The detailed list of items is given in [53].

Mass inventory

It is commonly recognised that the costing of the groups 2,4,5 and 10 requires setting up a detailed physical and radiological inventory under the form of database. For a component to be dismantled, typical input data are:

1. Its localization (i.e. facility, building, zone, room);
2. The average radiological conditions of the room concerned;
3. Its classification (i.e family and sub-family);
4. Its functionality by identification of the system or function to which it belongs;
5. Its physical characteristics (i.e. material, weight, gross volume (when relevant), total surface, mean thickness);

6. Its radiological characteristics (i.e. contamination type (β, γ or α, β and γ) and level, activation level, typical dose rate, isotopic vector).

Detailed decommissioning activities and time schedule

The cost calculation model strongly depends on a WBS - hierarchical project model which splits up the activities into the smallest possible, controllable and individually calculable units. Those units could be finally sequenced, assigned, scheduled and financial estimated. Hence, the budget is nothing more than the project plan, based on the activities plan or WBS, expressed in monetary terms.

15.1.3 Results of preliminary cost estimation

Results of Preliminary Decommissioning Plan (PDP) [1] were taken as basis for INPP decommissioning cost calculation (cash flow and global cost).

PDP was made in 1999 and lot of assumptions and data provided (like cost of external facilities, man-power, waste management associated costs and etc.) need to bee revised. One revision was made by DPMU at beginning of 2002 and associated methodology and results were provided in "DPMU report on PDP review" [19].

The present issue of the FDP (issue 05) updates the decommissioning costs provided in previous issues.

Taking into account among others the general decommissioning planning as given in figure 5.4 of the FDP, the estimates of the cash flow and of the yearly manpower required for the decommissioning have been updated for the period 2004 – 2020 in document in reference [96]. Table 15.5, hereafter, corresponds to Table 2.1 of this document, expanded to cover the period 2020 – 2029. This table constitutes the best available approach of the estimates of cash flow and manpower at the present stage.

In the frame of the here before mentioned assumptions, and taking into account an averaged manpower cost at the Plant of 6 €/h, the immediate dismantling decommissioning cost is estimated to 1241 M€ (2002 euros). In those conditions, the manpower cost amounts to some 25 % of the total decommissioning cost.

It should be mentioned that this cost estimate, and the other decommissioning costs estimates given later in this section, do not take into account any additional costs for contingencies, i.e. additional costs that would result from circumstances beyond control. Such circumstances could be (see item 12.0400 of [91]):

- changes caused by incomplete design, documentation;
- changes resulting from unforeseen, uncertain and/or unpredictable conditions, such as construction work disturbances caused by decommissioning operations;
- expected costs/savings associated with projected market conditions.

(D1/D2,3,4/D5,D6) (2)			7.39	59.45	24.43	28.00	34.00	18.00	20.00	4.00									
Training Centre Adaptation (3)				1.00	2.50	1.50	1.00												
	General planning (4)																		
	Manpower (man*years)			160	100	100	100	100	50	50	50	50							
	Cost of Manpower (MEURO)			1.58	0.99	0.99	0.99	0.99	0.50	0.50	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Invest + consum. (MEURO)				0.70														
	Budget (MEURO)			1.58	1.69	0.99	0.99	0.99	0.50	0.50	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Shut down of the plant (5)																		
	Manpower (man*years)			150	435	435	335	335	235	235	200	200							
	Cost of Manpower (MEURO)			1.49	4.31	4.31	3.32	3.32	2.33	2.33	1.98	1.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Invest + consum. (MEURO)				15.30	15.30	8.01	5.30	5.30	5.30	5.30	5.30							
	Budget (MEURO)			1.49	19.61	19.61	11.33	8.62	7.63	7.63	7.28	7.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	SF decay period (6)																		
	Manpower (man*years)			50	135	135	135	155	155	155	100	100							
	Cost of Manpower (MEURO)			0.50	1.34	1.34	1.34	1.53	1.53	1.53	0.99	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Invest + consum. (MEURO)			0.50	1.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80							
	Budget (MEURO)			1.00	3.14	2.14	2.14	2.33	2.33	2.33	1.79	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Prep. for dismantling (7)																		
Unit 1	Manpower (man*years)			50	270	345	125	125	100	190	170	170	170	110					
	Cost of Manpower (MEURO)			0.50	2.67	3.42	1.24	1.24	0.99	1.88	1.68	1.68	1.68	1.09	0.00	0.00	0.00	0.00	0.00
	Invest + consum. (MEURO)				8.78	1.54	1.54	10.88	9.55	1.54	1.54	4.04	1.94	1.54					
	Budget (MEURO)			0.50	11.45	4.96	2.78	12.12	10.54	3.42	3.22	5.72	3.62	2.63	0.00	0.00	0.00	0.00	0.00
	Dismantling&clearance (8)																		
	Manpower (man*years)						280	230	185	280	325	325	230	185	335	340	330	310	285
	Cost of Manpower (MEURO)			0.00	0.00	0.00	2.77	2.28	1.83	2.77	3.22	3.22	2.28	1.83	3.32	3.37	3.27	3.07	2.82
	Invest + consum. (MEURO)						5.35	5.35	5.35	5.35	5.35	5.35	5.35	6.04	21.40	21.40	15.75	17.36	17.36
	Budget (MEURO)			0.00	0.00	0.00	8.12	7.63	7.18	8.12	8.57	8.57	7.63	7.87	24.72	24.77	19.02	20.43	20.18
	Project management (9)																		
	Manpower (man*years)				230	230	230	230	230	230	230	230	230	230	230	230	230	230	230
	Cost of Manpower (MEURO)				2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28
	Invest + consum. (MEURO)																		
	Budget (MEURO)				2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28
	Unit 1 man*years total:			410	1170	1245	1205	1175	955	1140	1075	1075	630	525	565	570	560	540	515
	Unit 1 Meuro total:	*0.00*	*0.00*	*4.6*	*38.2*	*30.0*	*27.6*	*34.0*	*30.5*	*24.3*	*23.6*	*26.1*	*13.5*	*12.8*	*27.0*	*27.0*	*21.3*	*22.7*	*22.5*

Invest + consum. (MEURO)				1.00	2.30	0.30	0.30	0.30	0.30	0.30	2.60	0.30	0.30	0.30	0.30	0.30	0.30	2.60
Budget (MEURO)			0.00	1.00	2.30	0.38	0.38	0.38	0.38	0.38	2.68	0.38	0.38	0.38	0.38	0.38	0.38	2.68
NEAR SURFACE (11)																		
Manpower (man*years)											33	33	33	33	33	33	33	33
Cost of Manpower (MEURO)			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Invest + consum. (MEURO)					3.40	3.40	3.40	36.00	36.00	36.00								
Budget (MEURO)			0.00	0.00	3.40	3.40	3.40	36.00	36.00	36.00	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Bitumized vaults upgrading (12)																		
Manpower (man*years)					40	40	20											
Cost of Manpower (MEURO)			0.00	0.00	0.40	0.40	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Invest + consum. (MEURO)					1.60	1.60	0.80											
Budget (MEURO)			0.00	0.00	2.00	2.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Future repositories man*years total:			0.00	0.00	40.00	48.00	28.00	8.00	8.00	8.00	41.00	41.00	41.00	41.00	41.00	41.00	41.00	41.00
Future repositories Meuro total:	*0.00*	*0.00*	*0.00*	*1.00*	*7.70*	*5.78*	*4.78*	*36.38*	*36.38*	*36.38*	*3.01*	*0.71*	*0.71*	*0.71*	*0.71*	*0.71*	*0.71*	*3.01*

Unit 2 and Common Facilities on Site and Buildings demolition	Cost of Manpower (MEURO)								1.09	0.69	0.69	0.69	0.69	0.35	0.35	0.35	0.00	0.00	0.00	0.
	Invest + consum. (MEURO)								0.70											
	Budget (MEURO)								1.79	0.69	0.69	0.69	0.69	0.35	0.35	0.35	0.00	0.00	0.00	0.
	Shut down of the plant																			
	Manpower (man*years)								150	435	435	335	335	235	235	200				
	Cost of Manpower (MEURO)								1.49	4.31	4.31	3.32	3.32	2.33	2.33	1.98	0.00	0.00	0.00	0.
	Invest + consum. (MEURO)									6.00	5.50	4.00	3.50	3.50	3.50	3.50				
	Budget (MEURO)								1.49	10.31	9.81	7.32	6.82	5.83	5.83	5.48	0.00	0.00	0.00	0.
	SF decay period																			
	Manpower (man*years)								50	150	150	150	150	150	150	120				
	Cost of Manpower (MEURO)								0.50	1.49	1.49	1.49	1.49	1.49	1.49	1.19	0.00	0.00	0.00	0.
	Invest + consum. (MEURO)									1.80	0.80	0.80	0.80	0.80	0.80	0.80				
	Budget (MEURO)								0.50	3.29	2.29	2.29	2.29	2.29	2.29	1.99	0.00	0.00	0.00	0.
	Prep. for dismantling																			
	Manpower (man*years)						50	160	160	80	50	50	150	200	150	150	150	150	50	5
	Cost of Manpower (MEURO)								1.58	0.79	0.50	0.50	1.49	1.98	1.49	1.49	1.49	1.49	0.50	0.
	Invest + consum. (MEURO)									5.20	1.00	1.50	6.50	5.00	1.00	1.00	1.00	2.50	1.20	0.
	Budget (MEURO)								1.58	5.99	1.50	2.00	7.99	6.98	2.49	2.49	2.49	3.99	1.70	1.
	Dismantling&clearance																			
	Manpower (man*years)									225	185	150	225	260	260	285	250	270	275	26
	Cost of Manpower (MEURO)								0.00	2.23	1.83	1.49	2.23	2.57	2.57	2.82	2.48	2.67	2.72	2.
	Invest + consum. (MEURO)									5.35	5.35	5.35	5.35	5.35	5.35	5.35	6.00	10.50	10.50	8.
	Budget (MEURO)								0.00	7.58	7.18	6.84	7.58	7.92	7.92	8.17	8.48	13.17	13.22	10.
	Project management																			
	Manpower (man*years)								215	215	215	215	215	215	215	215	215	215	215	21
	Cost of Manpower (MEURO)								2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.
	Invest + consum. (MEURO)																			
	Budget (MEURO)								2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.
	Unit 2 & Com. man*years total:								685	1175	1105	970	1145	1095	1045	1005	615	635	540	53
	Unit 2 and Com. Meuro total:								*7.48*	*29.98*	*23.59*	*21.25*	*27.49*	*25.49*	*21.00*	*20.60*	*13.09*	*19.29*	*17.05*	*13.*
Total man*years		*0*	*0*	*410*	*1170*	*1285*	*1253*	*1203*	*1648*	*2323*	*2188*	*2086*	*1816*	*1661*	*1651*	*1616*	*1216*	*1216*	*1096*	*10*
Total MEuro:		**0**	**7**	**65**	**66**	**67**	**68**	**57**	**94**	**95**	**84**	**50**	**42**	**39**	**49**	**48**	**35**	**43**	**43**	**4**

The definitions and key assumptions used for the set-up of Table 15.5 are the following (see in the table the identification of the comments):

(1) Wages: 6 €/hour and 1650 h/year, i.e. 9.9 K€/Man.year.

The INPP personnel average actual wage was given at 17.34 Litas/h (except Social Security and taxes), i.e. 5.05 €/h. The Social Security and taxes do represent some 31 % increase, i.e. the average paid wages would amount: 6.61 €/h.
On the basis of the assumption that EBRD would not pay for the taxes, the round 6 €/h was considered as reference figure.

(2) The cash flow of the B packages corresponds either to the actual expenditure spreading for the already awarded contracts (B5, B6) or to the payment schedule mentioned in the tender documents for the to be awarded contracts (B1 – B4).

(3) The cash flow of units 1 and 2 post-shutdown, defuelling, decontamination and dismantling activities is in accordance with:

- *the planning of those activities as mentioned in Chapter 5 and on Figure 5.4 of the FDP;*
- *the data of INPP document "Prospective Configuration of Unit 1 during its Decommissioning" – see also (5)+(6)+(9) hereafter .*

(4) General Planning mainly includes:

- *conceptual and detailed planning preparation,*
- *preparation of licensing documents,*
- *data collection,*
- *expertise + licensing costs.*

(5) Unit shutdown mainly includes:

- *procedures, licensing procedures,*
- *unloading of the reactor,*
- *modifications of existing installations, isolation, drain down, system conservation activities,*
- *operation/maintenance of the systems kept in service,*
- *preliminary cleaning/decontamination of rooms for dose rate reduction,*
- *related waste and operational waste management,*
- *health physics activities associated to the above works.*

(6) Spent Fuel Decay Period mainly includes:

- *licensing activities,*
- *fuel handling activities in the pools (cutting of long fuel assemblies, integrity monitoring, handling of cut assemblies, loading of the casks and their transportation to the ISFSF),*
- *fuel assembly transportation to Unit 2 for recycling,*
- *operation and maintenance of the systems kept in service,*
- *related waste management,*
- *health physics related activities.*

(7) Preparation for Dismantling mainly includes:

- *planning activities, licensing activities,*
- *procurement/ installation of new installations,*
- *modification of existing systems,*
- *in-line decontamination of large systems (MCC, PCS, CPSCC, LSW, pools and pool cooling systems),*
- *related waste management,*
- *health physics activities.*

(8) Dismantling and clearance mainly includes:

- *planning/licensing activities,*
- *local preparatory works (installations of scaffoldings, tools, lighting, mobile shielding, local confinment…),*
- *dismantling of contaminated/activated components,*
- *decontamination of segmented components (when economically justified), of building surfaces,*
- *post-dismantling activities (room cleaning, removal of scaffolding, tools,…),*
- *related waste management,*
- *measurement for evidence of non radioactivity,*
- *removal of structures and buildings,*
- *related health physics activities.*

(9) Project Management mainly includes:

- *general administration of the site, of the departments,*
- *project management,*
- *on-site support.*

(5)+(6)+(9) Bases for cost calculation:

Appendix 3 of INPP document "Prospective Configuration of Unit 1 during its Decommissioning" gives:

- *the annual manpower cost corresponding to the reactor defuelling period, i.e. 24.5 M Litas/y (7.1 M€/y);*
- *the annual maintenance operation costs during the same period, i.e. 18.2 M Litas/y (5.3 M€/Y).*

On the basis of an average yearly wage of 9.9 K€/y (see item (1)), the corresponding manpower amounts to $\frac{24.510^6}{3.45*9.910^3} = 717$ *individuals/y, all divisions included. An average manpower of 755 individuals was taken into account during the period 2005-2008 (see Table 15.5 – Unit Shutdown, Spent fuel Decay Period, Project Management), i.e. until the reactor complete defuelling. The average manpower was then reduced to 525 individuals during period 2009-2012 (pool defuelling phase). The annual maintenance and operation costs are included in "investments + consumables" of Unit Shutdown and Spent Fuel Decay Period. A similar approach was considered for the Post-shutdown and Defuelling Phases of Unit 2.*

(10) Landfill Site

<u>Bases for cost calculation</u>: Studsvik feasibility study – most expensive concept.

- *For a 12200 m^3 of waste (net volume), i.e. a 20000 m^3 tranch total volume (including containers volume, filling rate of containers = 80%, free volume between containers), the construction cost amounts to 2.3 M€. Three tranches are planned and must be commissioned in 2007, 2012 and 2019.*

- *Consumables:*

  - *the rental of dump truck + lifting device: 0.12 M€/y (Studsvik Study),*
  - *the half-iso containers into which the solid waste (other than the pre-compacted bales) are put:*

    Volume occupied by the half-iso containers: 36290 m^3 say 40000 m^3 (see Table 10.19 of the present FDP Issue 05).

    Volume of one half-iso containers: 19 m^3 (see section 10.6.2 of the present FDP).

    Number of half-iso containers: $\frac{40000}{19} = 2105$ *and 2000 €/cont.*

    Cost of containers: $2105 * 2000 = 4.3$ *M€.*

    Annual consumption $\frac{2105}{23} = 92$ *cont/y = 0.184 M€/y*

- *Manpower: 4 workers according to Studsvik study, say 8 workers in the present case.*
- *Note: an additional amount of 1.0 M€ is included in 2005 for licensing and design.*

(11) Near-surface Repository

<u>Bases for cost calculation</u>: SKB – SWECO International Study for INPP

Construction phase

Table 15.6 NSR construction costs

Item	***2006***	***2007***	***2008***	***2009***	***2010***	***2011***
Planning + design	*3.4*	*3.4*	*3.4*			
Construction[1]				*34.0*	*34.0*	*34.0*
Construction facilities				*2.0*	*2.0*	*2.0*
Total	*3.4*	*3.4*	*3.4*	*36.0*	*36.0*	*36.0*

Closure of the repository

The closure works of the repository will start in 2020 and end up in 2029. An amount of 117 M€ is estimated for these works, i.e. an annual expenditure of 11.7 M€/y.

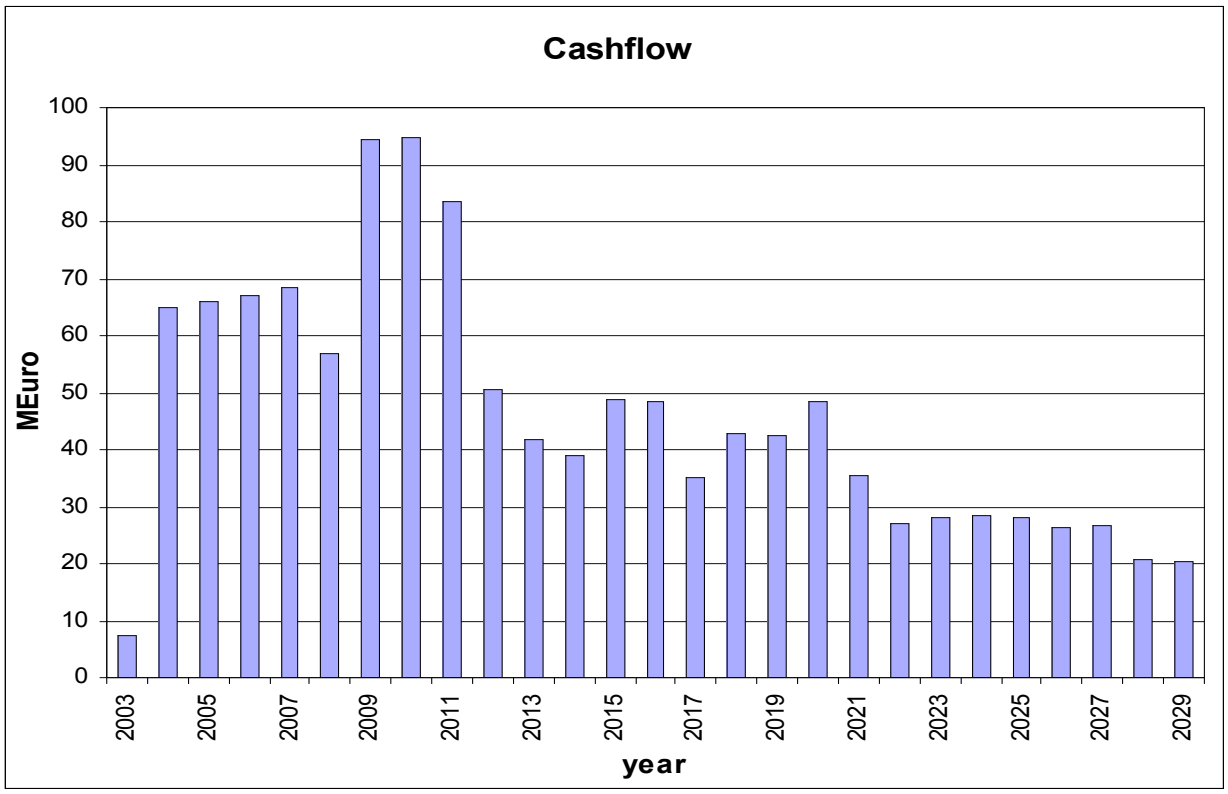
Operation of the repository

An amount of 5.8 M€ is estimated for the period 2012-2029, i.e. 0.33 M€/y. This corresponds to a manpower of $\frac{330}{9.9} = 33$ *man/years, including supervisors, engineers, documentation management, operators and guards.*

[1] The construction costs correspond to the upper range value indicated in the SKB – SWECO study.

This decommissioning cost will be distributed over a period of time starting in 2003 and ending by 2029, when the decommissioning of the whole Plant will be completed. The cash flow distribution is the following:

Figure 15.1 Decommissioning cash flow (average manpower at 6€/h)



This cost estimate does not take into account:

- The possible surveillance costs related to the waste to be stored on the site beyond 2029, such as the spent fuel, the graphite and the other waste not suitable for near-surface disposal (groups D, E, F waste) and the maintenance costs of the corresponding storage facilities. Actually, and in agreement with recommendation of an International Expert Review Group, an amount of 500 €/m^3 has been taken into account to cover the investment and the interim storage costs of groups D, E and F waste, at least, till 2029. The extent to which this amount is sufficient to cover the storage of this waste beyond 2029 is not known, namely because the storage period is not known.
- The conditioning and final disposal of the above waste, taking into account the high uncertainties related to the conditioning techniques which will be agreed upon by VATESI and, most of all, to the final disposal costs into cavities at intermediate depth (graphite) and into deep geological repositories (spent fuel, groups D, E, F waste).
- The possible surveillance and maintenance costs of the disposal facilities which will remain on the site after 2029, i.e. the landfill for the very low level waste and the bituminized waste upgraded storage vaults. The surveillance and maintenance costs of these facilities beyond 2029 were not taken into account.

The SKB-SWEVCO International – Westinghouse Atom Joint Venture study estimated the NSR cost, including site selection, design, construction and operation till 2040, to lay between 140-240 M€. The upper range value of 240 M€, leading to a unit disposal cost of 2400 €/m^3, was taken into account in the decommissioning costs. The active surveillance cost to last some 100 years and the passive surveillance costs to last some additional 200 years after the NSR closure were not taken into account, due to the uncertainties on the wages over such long time scales.

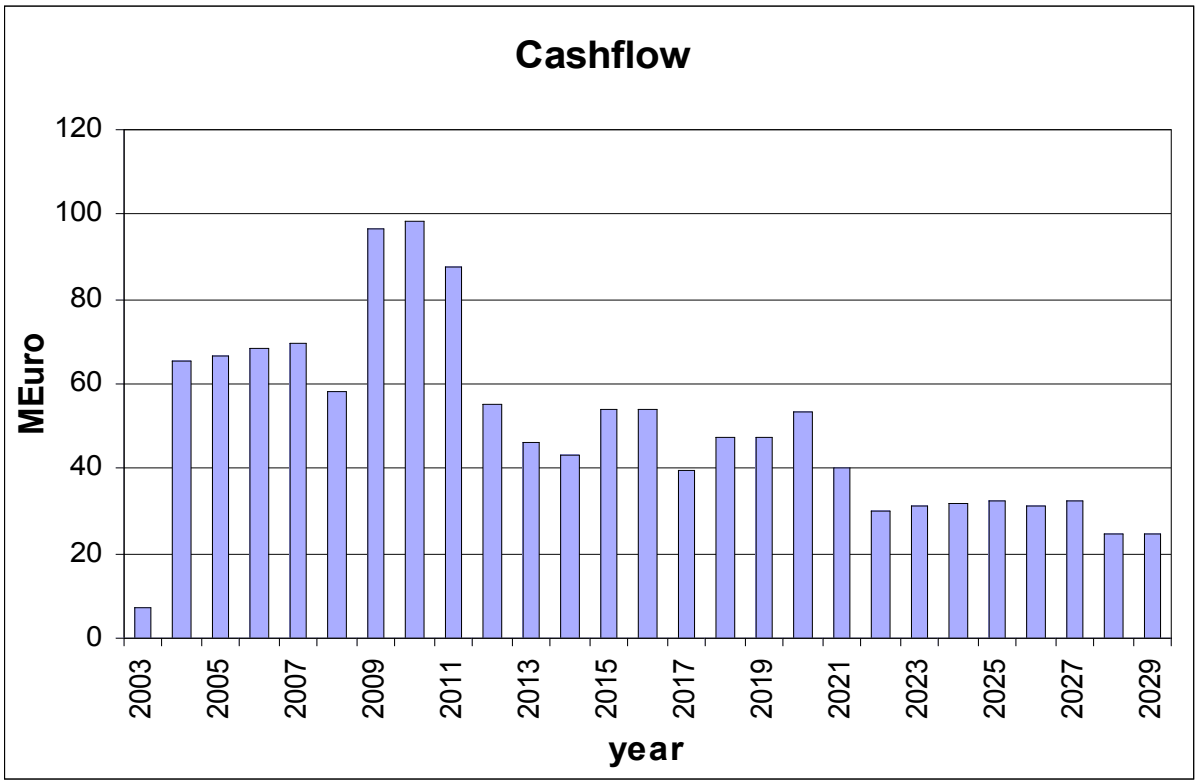
Wages have a significant impact on the total decommissioning cost. In some Western decommissioning projects, manpower costs may constitute as much as 65 % of the total decommissioning cost. Therefore, the current INPP-FDP considers, for indicative purpose, two scenarios for the wages evolution in the future.

The first is based upon an evolution of wages used by the Ministry of Social Security and Labor for the modeling of pensions. The real rate growth (i.e. above inflation) considered varies according to the following:

Year or Period	2003 - 2004	2005	2006 - 2008	2009	2010 - 2014	2015 - 2019	2020 - 2024	2025 - 2029	2030 - 2034
Real wage growth (%)	2.2	1.8	1.9	2	2.1	2.6	2.4	2.3	2.1

The total decommissioning cost is estimated in that case to reach 1337 M€, showing the small impact (~ 8 %) of the assumed wage evolution on the overall cost and cash flow (see Figure 15.2).

Figure 15.2 Decommissioning cash flow (wages evolution Ministry of Social Affairs)



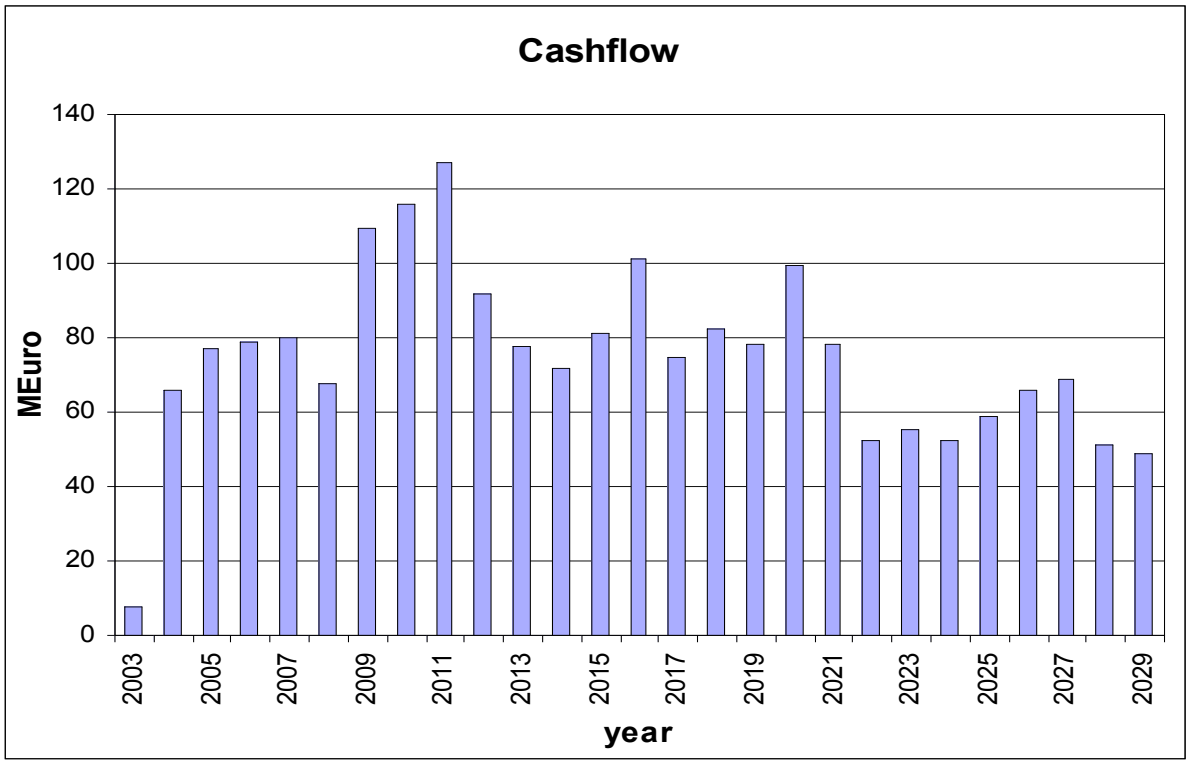
The second one considers that accession to the EU could drive manpower costs in Lithuania to European values in the long term, according to a progressive increase from the present average rate at INPP up to 40 €/h by year 2026, i.e.:

Year or period	2002-2004	2005 - 2010	2011 -2015	2016 - 2019	2020 -2025	2026 -2029
Average wage (€/h)	7.6	11.6	18	25.8	34.60	40

This scenario eventually brings the cost estimate to 2019 M€ and the manpower share to some 54 % of the total.

Associated cash-flow needs are given in figure below:

Figure 15.3 Decommissioning cash flow (wages progressive increase up to 40 €/h)



As the Lithuanian Government selected the immediate Dismantling option irrespective to the Net Present Value (NPV) of the total decommissioning cost and of cash flow considerations, the NPV becomes purely informative and sensitivity calculations are no longer relevant in this FDP.

By the time of issuing the first version of the FDP, supporting the deferred Dismantling option, on the basis of, among others, NPV and cash flow considerations, a discount rate of 3% above inflation over a long period was considered as a reasonable approach.

The selection of a net discount rate is a complex process that integrates considerations linked to:

- The private profitability of the investment;

- The relative weight of positive/negative externalities of the electrical production;
- The time scales of considered scenarios (20, 30, 50 years or larger).

Due to the many uncertainties about the evaluation of the mentioned international economics over long periods (more than 30 years), experts generally recommend to use two sets of discount rates:

- First set covering time scale up to 30 years: net discount rates are then typically in the range 3-5 % [82]
- Second set applicable to the period beyond 30 years: net discount rate of 2% is typical [83].

The time scale of INPP decommissioning (Immediate Dismantling) being of 25 – 30 years, a net discount rate of 3% is selected here.

15.2 Funding of the INPP Decommissioning

There are presently two different available sources for funding of INPP Decommissioning, namely:

1. The Ignalina International Decommissioning Support Fund (IIDSF);
2. State Enterprise Ignalina NPP Decommissioning Fund (SEIDF)

15.2.1 The Ignalina International Decommissioning Support Fund

Present status of the IIDSF

During the Donors Conference held in Vilnius in June 2000, international donors (EC and some European Countries) promised to grant INPP pre-decommissioning activities and in December 2001 a total of **145,63** M€ were contributed. This fund is managed by EBRD and will be used to fund INPP pre-decommissioning investment projects.

Additional Financing Memorandum Nr. LI "Special Programme to Support Decommissioning of NPP and Consequential Measures in the Energy Sector – Lithuania" was signed on the 17th of December 2001 between the EC and the Government of Lithuanian Republic. According to this memorandum, an amount of **54** M€ was additionally allocated to IIDSF for INPP Decommissioning.

Future expectations for additional INPP decommissioning funding:

According to the "Treaty of Accession to the European Union 2003", Protocol No. 4 "On The Ignalina Nuclear Power Plant In Lithuania" section 5, "…..For the period 2004-2006 the Ignalina Programme shall amount to EUR **285** million in commitment appropriations, to be committed in equal annual tranches." This would represent some **95** M€/year.

15.2.2 State Enterprise Ignalina NPP Decommissioning Fund

Present status of the SEIDF

According to the Lithuanian Government decree No 1149p (adopted 23/11/92), 1.3% of electricity production revenue were dedicated to INPP Decommissioning fund. This appeared to be insufficient as until mid-1995 only some 12 million Lt were accumulated.
On 02/11/1995 the Lithuanian Government adopted the Decree No 1403 which stated, that provisions for Interim Spent Fuel Storage Facility and Decommissioning Fund should be included in electricity price. Deduction of 16,6% of electricity production revenue in 1995 and 1996 was accordingly affected.

New Decree adopted on 02/02/96 set the deduction at 4.4% which was again modified to 6% on 01/01/99.

As per 01/01/2003, SEIDF accumulates a total of ~**183.5** million Lt.

By 01/01/2004, the global available fund is expected to amounts to ~**214.4** million Lt.

Future expectations for additional INPP decommissioning funding:

Operation of both INPP Units until end 2004 is to contribute to some additional **17.4** million Lt.

15.2.3 Global INPP Decommissioning Funds status

As per 01/01/2003 the global available funding is of (considering already spent 5.801M€ from IIDSF):

145.63 + 54 –5.801 + 183.5/3.4528 ≈ **247 M€**

Until final shutdown of Unit 1 (31/12/2004) it is expected to allocate additional:

285/3 + 17.4/3.4528 ≈100 M€

15.2.4 Securing the future continuous funding of INPP Decommissioning

A continuous funding of the decommissioning activities is a key safety requirement. After Unit 1 RFS (31 December, 2004), the future funding sources are expected to be the following:

- EU:
  - About 95 M€/y for 2005 and 2006, according to section 5, Protocol No. 4 of the "Treaty of Accession to the European Union 2003" (see § 15.2.1)
  - The future EC additional funding and funding schedule are the objects of on-going negotiations with the Lithuanian Government, on the basis of Article 3, section 1 of the Treaty mentioned here before: "…Recognizing that the decommissioning of the Ignalina Nuclear Power Plant is of a long-term nature and represents for Lithuania an exceptional financial burden not commensurate with its size and economic strength,

the Union shall, in solidarity with Lithuania, provide adequate additional Community assistance to the decommissioning effort beyond 2006."

- SEIDF: This fund will still be supplied by a deduction of the electricity sales from Unit 2 operation until its final shutdown.

It should also be noted that the electricity tariffs in Lithuania cover, among others, the costs of "services of public interest". Part of the money collected in the frame of these "services of public interest" could possibly be transferred to the SEIDSF, should the Lithuanian government take such a decision. Furthermore, the Lithuanian government could also decide to increase, in the future, the costs of those "services of public interest" in order to bear a more important share in the INPP decommissioning expenses.