

# HOW TO PAY?

Financing decommissioning of nuclear power plants



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# PREFACE

This report is a result from the project “*From closed rooms to openness*”, supported by Norwegian Radiation Protection Authority. In 2003, a network was started by Naturvernforbundet/Friends of the Earth Norway and the Russian non-governmental environmental organisations Green World, Kola Environmental Centre and Center of Nuclear Ecology and Energy Policy of the Socio-Ecological Union. The participating NGOs in the network have changed along the way, but the mission has always been promotion of safe, socially and ecologically acceptable decommissioning of nuclear power reactors that have reached their design limit. It is necessary to consider the world’s best experiences on decommissioning, and secure openness and participation of all interested stakeholders, based on democratic principles. As the situation for Russian NGOs have worsened, several of the network participants have been declared “Foreign Agents” and been forced to close.



# SUMMARY AND RECOMMENDATIONS

How to finance decommissioning of nuclear power plants? When the operating time of a nuclear reactor is passed, it must be dismantled, and radioactive parts must be treated and stored. Following the “Polluter Pays Principle” the price paid for electricity generated by nuclear power should include the costs of cleaning up. This means that the dismantling of nuclear facilities and treatment and storage of nuclear material must be paid either by the electricity consumers directly, or from the companies earning money from selling nuclear electricity.

In this report, we have studied the solutions chosen in Sweden, the United States and Germany, to find learning points for Russia. As the report shows, all countries demand that electricity producers set aside money for decommissioning. However, their solutions vary.

Generally, too little money is set aside for decommissioning and waste handling. As the report shows, all countries run the risk of not having collected enough in time for closure, especially if the reactors should close after their designed lifetime. However, if nuclear power is demanded to pay the real costs – something which seems fair – nuclear power can become too costly to operate. As the situation in Sweden shows, if the fees are raised to the necessary level to accumulate enough funds for the decommissioning, the nuclear reactors may be run out of business. In an open electricity market,

such as the Swedish one, nuclear reactors may already be struggling to make a profit because electricity prices are lower than their long-term running costs. If the struggling reactors are then closed, they will not generate more fees for the decommissioning fund.

Seen from this perspective, funding from budget is a better option. However, funding from budget, or taxes, is always risky. They run the risk of being diverted to other, politically more important purposes with more short-term benefits. Also, funding from budget can be seen a breach of the “Polluter Pays Principle”.

But even following the “Polluter Pays Principle”, there are different suitable approaches. In Sweden, there is one common fund for waste and decommissioning costs for all operators. In the United States, each licensee has its own decommissioning fund or has alternative solutions to provide reasonable assurance that they will accumulate adequate funding. USA also has a federal nuclear waste fund, but collection of money has been halted. In Germany, state-owned reactors are decommissioned from the state budget but private-owned reactors must bear their own costs. In a 2016 agreement, the government will take over the responsibility for long-term waste storage, and licences pay for decommissioning and preparations of waste. In Russia, money is set aside for decommissioning and radioactive waste treatment. The amount set

aside has increased compared to 10 years ago, but still too little money is collected, and money is already used on closed reactors. Already now Russia uses budget money for decommission purposes, even though most of the old and out-dated reactors are still operating.

For all countries, including those studied here, there are uncertainties about costs for decommissioning and waste handling. This is due to a lack of experience of full-scale decommissioning. For waste treatment, no final solutions have been found and the task is complicated by the unforeseeable time perspective. Even temporary solutions are costly and often conflicts arise.

Generally, we recommend all countries to follow our five criteria for decommission funds; individuality, transparency, self-repayment, independence and compliance regarding their decommissioning plans.

For Russia, this means that

- Money for decommissioning from the operator should be increased, to pay for a larger share of decommissioning, including handling of spent nuclear fuel.

- Openness, transparency and accountability should be improved, here much can be learned from Sweden.

- To secure independence, the decommission fund should be moved from Rosatom.

- Regarding individuality, we recommend one fund per power plant as in the United States or at least specifically designed parts of the fund as in Sweden.

- The decommission strategy of immediate dismantling should be chosen to avoid a future situation where decommission tasks are piling up without the necessary funding.



# 1. INTRODUCTION

The scope of this report is to share international experience on systems for collecting funds for decommissioning. We wanted to investigate what could work for improved decommissioning planning in Russia. Previously in our project work, we have often looked at best international practice, to find learning points and useful ideas.

We start in chapter 2 by explaining why collection of funds for decommissioning is necessary, and discuss ethical considerations in chapter 3. Then, international rules and recommendations are presented in chapter 4. In chapter 5 we present case studies based on the solutions used in USA, Sweden, Germany and Russia. In chap-

ter 6 we compare the solutions, and in chapter 7 we sum up what could be learned.

We have chosen to include funds for spent nuclear fuel and radioactive wastes, since it can be regarded as an important part of decommissioning, and it differs where countries draw the line, if any. For instance, the USA regards low-level waste as part of decommissioning to be funded by decommission money, the same for storage of spent nuclear fuel until it can be handed over to the authorities for depositing. Sweden has one trust fund for both decommissioning and handling of waste and spent fuel.



## 2. WHY IS IT NECESSARY TO COLLECT FUNDS, AND HOW MUCH FUNDS ARE NEEDED?

The rationale for collecting funds for decommissioning seems obvious. Both dismantling of the facilities and treatment and storage of radioactive wastes of all kind are quite costly, and lack of funds can pose a risk that it will not be done properly and safely. Following the polluter pays principle the price paid for electricity generated by nuclear power should include the costs of cleaning up. However, the collection of funds did not commence when the first nuclear power plants started their operations.

Already in the early days of decommissioning, decommission costs varied a lot. For example, in 1985 IAEA pointed out that even for facilities of same type and capacity, estimates “hardly resemble one another” (IAEA 1985:13), and showed that decommission costs ranged from USD 103 million to USD 144 million (ibid:14). So, it is understandable that IAEA called for “efforts to standardize the methodology for estimating decommission costs” (ibid:13).

Since 1985, we would expect a lot of experience to have been gathered from nuclear power plant decommissioning. Yet, the standardized methodology that is being used in the US today, the NRC’s decommission formula, is based on studies published in 1978 and 1980 (GAO 2012:6). This has raised concern that collected money might be insufficient.

Also, regarding treatment and storage of different kinds of nuclear wastes, costs have been uncertain and also increasing with stricter safety standards.

In Germany, the company Vattenfall stated that from previous experience, costs for the post-operation period, and decommissioning work ranges from 500 million to 1 billion euros per nuclear power plant (NPP), depending on its size, age and run-time. In another case RWE estimates that costs of decommissioning two reactor blocks at Biblis in Germany in the next 15 years will be “considerably higher than 1 billion euros” (Clean Energy Wire 2015a).

In 2014 IAEA estimated the cost of decommissioning to 500 million US dollars or about the same amount in Euros per January 2017. Based on analysis, in France the cost of decommissioning nuclear power plants will amount to an average of about 350 million Euros. Similar estimates for the Japanese nuclear power companies are equivalent to approximately US dollars 600 million per unit. Furthermore, including all expenditures on treatment of radioactive waste and the cost of construction of centralized storage further increases the cost. For example, the same estimates for the French nuclear power plant increased to about 1.1 billion US dollars, an analysis for Germany leads to a figure of



2.2 billion US dollars per unit. The process of closing six nuclear power plants in Greifswald in Germany lasted 35 years and cost about 3.2 billion Euros (Nuclear Expert 2015).

As figure 1 shows, the estimated costs of decommissioning vary between European countries. According to Thomas, not all differences can be fully explained, but there are some explanations (Thomas 2017). For instance, Italy has a variety of technology (ibid.), which would make standardization difficult. It should be noted that these costs are only estimates and the lack of experience means that the actual costs can be quite different.

The closure of the Ignalina nuclear power plant in Lithuania was in its initial decommissioning plan in 2005 estimated at 1.239 billion Euros, and it's the decommissioning was planned to be completed within 24 years, by 2029. In the new version of the final decommissioning plan, approved by the Ministry of Energy in Lithuania in 2014, there is a need for an additional 2.6 billion euros and 9 more years. Lithuania has fully spent the accumulated decommissioning fund and all work on decommissioning is now dependent on finances from EU and other donors (Kuznetsov 2016).

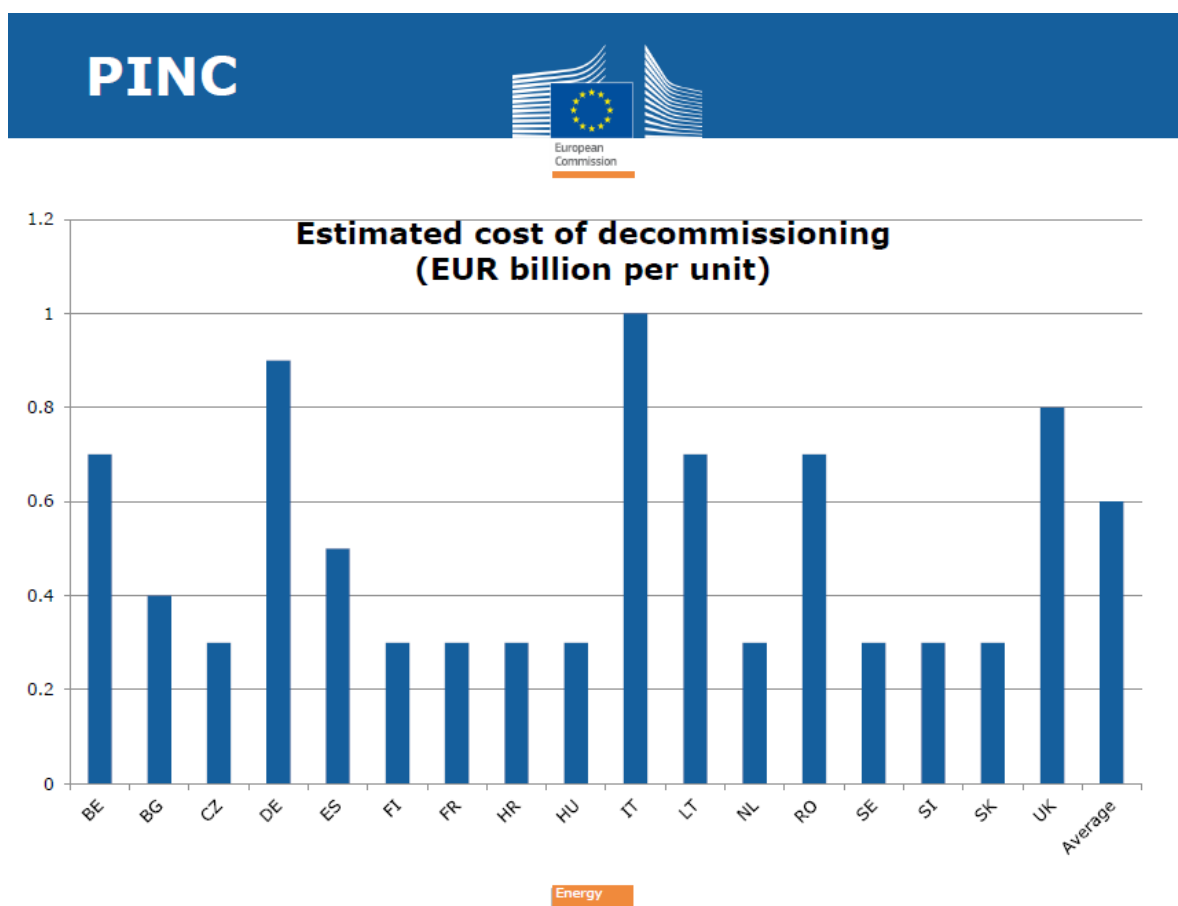


Figure 1: Differences in estimated cost of decommissioning (source: Thomas 2017)

### 3. ETHICAL CONSIDERATIONS – PRINCIPLES FOR DECOMMISSIONING

The “Polluter Pays Principle” is enacted to make parties responsible for producing pollution, responsible for paying for the damage done to the natural environment. Following this principle, those who earn money on selling nuclear power, should be responsible for cleaning up. This includes dismantling the power plants and taking proper care of all harmful wastes. This obviously doesn’t mean that the nuclear operator decides what must be done; this is the prerogative and responsibility of the regulating authority. But it does mean that the owner of the nuclear power plant is responsible to do the clean-up, and pay for it.

A report made by the Wuppertal Institute in 2007 compares different decommissioning funds methodologies for nuclear installations in the EU (Wuppertal 2007c). It ends up with the following general conclusions and recommendations:

Over-riding principles and general steps to eliminate / mitigate risks:

- Funds should be adequately available when needed
- Polluter pays principle to be fully adhered
- Public licensees should not pay decommissioning costs from current budget
- Financing schemes should eliminate or mitigate risks and uncertainties as far as possible.

Steps to achieve this include:

- Identification of risks/Uniform accounting treatment
- Increasing transparency and clarity
- Assuring a high degree of independence between actors in Governance chain, through
- Independence of licensing authority
- Full independence of decommissioning fund from operator
- Internal unrestricted decommissioning financing schemes do not secure minimum degree of independence necessary
- Separate power of authority to disposed of collected means of finance from bodies, responsible for collection and dispersal of funds
- Risk-adjusted investment policy

The report emphasises the “Polluter Pays Principle” and states that:

“Nuclear decommissioning liabilities include dismantling, decontamination, demolition and site clearance of the nuclear facility at the end of their lifetime, as well as for the storage, processing, conditioning and disposal of nuclear waste and spent fuel. A main imperative for the distribution of liabilities is the “Polluter Pays Principle” which is broadly accepted but not fully implemented in every country. Only in some countries (e.g. Finland, Sweden), the

“Polluter Pays Principle” is a legal requirement. The principle assumes the operator of the nuclear facility to be the “polluter” and to have the responsibility to finance and implement all decommissioning activities including nuclear waste management and final disposal operations. Furthermore, it implicitly assumes that the generation benefiting from a nuclear facility’s production should pay for the decommissioning.”

(Wuppertal 2007b).

## PRINCIPLES

In our Concept of a Decommission Plan for Old Nuclear Power Reactors – guiding principles from Environmental NGOs (Decommission Network 2008:28), we outline the following principles on which a decommission fund should be formed:

- Individuality. Each NPP should run its own decommissioning fund sufficient for solving the whole complex of related problems.

- Transparency. Fund expenditures on the power unit decommissioning should be published and kept under public control.

- Self-repayment. Means of the fund come from the transferred percentage of the revenues from electricity sold and other financial activities of the decommissioned NPP.

- Independence of Fund management from the operating utility. The fund should be managed by one of the federal ministries and controlled by the Board of Trustees which has federal, regional and municipal representatives.

- Strict compliance with the Decommission plan should be observed.

In chapter 6, we will use these principles to evaluate the chosen solutions of the different countries.

It should be noted that is not self-evident what is included in “the whole complex of related problems”, that money from the decommission fund should solve. For instance, we write in the concept (ibid:27) that the fund should foresee budgeting for

- power unit dismantling, radioactive waste and spent nuclear fuel disposal or long-term isolation for the whole period of their noxiousness for living systems;

- transformation of the municipal infrastructure in towns, which neighbour NPPs are planned for decommissioning;

- solution of the social adaptation problem for the workers of decommissioned NPP.



Oleg Bodrov from Green World presenting our Concept of a decommissioning plan for Rosatom and municipal leaders in Sosnovy Bor.

(Photo: Martin Ødegaard.)

## 4. INTERNATIONAL RULES AND RECOMMENDATIONS

The International Atomic Energy Agency (IAEA)'s safety standards for decommissioning of nuclear facilities states that

“Responsibilities in respect of financial provisions for decommissioning shall be set out in national legislation. These provisions shall include establishing a mechanism to provide adequate financial resources and to ensure that they are available when necessary, for ensuring safe decommissioning” (IAEA 2014:13).

This might seem self-evident, but as we will show in later chapters, concerns have been raised whether adequate financial resources for ensuring safe decommissioning will be available when necessary (See for instance GAO 2012 for USA and Clean Energy Wire 2016 for Germany).

More concretely, IAEA sets out the following five articles (IAEA 2014:13):

6.1. It shall be ensured that adequate financial resources to cover the costs associated with safe decommissioning, including management of the resulting waste, are available when necessary.

6.2. The cost estimate for decommissioning shall be updated on the basis of the periodic update of the initial decommissioning plan or on the basis of the final decommissioning plan. The mechanism used to provide financial assurance shall be consistent with the cost estimate for the

facility and shall be changed if necessary.

6.3. If financial assurance for the decommissioning of an existing facility has not yet been obtained, adequate financial resources shall be put in place as soon as possible. Approval of a renewal or extension of the authorization for operation of the facility shall include provisions for financial assurance.

6.4. In the event of a sudden shutdown of the facility, provisions shall be put in place to enable use of the financial resources for decommissioning when they are needed.

6.5. If the decommissioned facility is to be released with restrictions on its future use, financial assurances shall be such that financial resources are available for monitoring, surveillance and control of the facility throughout the necessary time.

Regarding 6.5, it should be noted that US environmentalists have opposed the possibility to release with restrictions (NIRS 2002:3). Contrary to this, Russian environmentalists have previously opened for releasing sites with restrictions, so-called “Brown field”, to reduce the costs of decommissioning (Decommission Network 2008:20). Both solutions can of course be in line with 6.5 above.

Regarding responsibilities, IAEA sets out the following responsibilities, shown in table 1. Following this, a claim that the licensees have responsibility to provide assurances and resour-

ces to cover costs of decommissioning has clear support from the IAEA. Apart from that, the main conclusion is that rules must be made.

**Table 1: Responsibilities set by IAEA (IAEA 2014:8-9).**

Government	“Establishing a mechanism to ensure that adequate financial resources are available when necessary for safe decommissioning and for the management of the resulting radioactive waste”
Regulatory body	“Establishing requirements for the licensee’s financial assurance for decommissioning and requirements for a mechanism to ensure that adequate resources will be available when necessary for safe decommissioning, in the case where the government has delegated these responsibilities to the regulatory body”
Licensee	“Estimating the cost of decommissioning actions and providing financial assurances and resources to cover the costs associated with safe decommissioning, including the management of the resulting radioactive waste” (ibid:9)



## 5. PRESENTATIONS FROM RELEVANT COUNTRIES

This project seeks to contribute to good decommission solutions for Russia. To do so, experiences from other countries are relevant. In previous reports, video documentaries and study tours, we have collected, and presented, international experiences with the purpose of providing useful examples and learning.

In this report, we have chosen to present systems for accumulating funds for decommissioning and nuclear waste treatment in the United States, Sweden and Germany. These are countries which have useful and relevant experience. For comparison, we briefly present the Russian solution also.

There are some common features, for instance in all 3 countries nuclear industry is responsible for paying for decommissioning of their own reactors following the polluter pays principle. Overall, there are common features. Looking closer, we see differences, as will be shown below.

### 5.1 THE UNITED STATES

The United States has different solutions for money to pay for nuclear wastes and decommissioning. For nuclear waste, there is a federal Nuclear Waste Fund, which started to collect funds in 1983. From 2014, further payments have been suspended since the progress on a disposal site has been terminated. In the meantime, high level nuclear waste is accumulating at the reactor

sites around the United States.

13 nuclear reactors in the United States have completed decommissioning, meaning everything on site are removed or decontaminated “to a level that permits release of the property and termination of the NRC licence” (NEI 2016). The United States Nuclear Regulatory Commission (NRC) oversees decommission processes at 19 reactors (NRC 2017a), and four reactors that are not regulated by the NRC have their radioactive contaminants encased in an entombment structure (NEI 2016).

100 reactors at 63 sites have licence to operate (NRC 2017b). The licensees are responsible for the storage of the spent nuclear fuel on or near the reactor sites, until the federal government has found a place to store the waste and subsequently takes over responsibility.

There is no common fund for decommissioning costs, but the Nuclear Regulatory Commission requires that every nuclear power plant company must provide financial assurance for decommissioning. This can be prepayment, insurance or parent company guarantee, or external sinking fund (NRC 2016). Trust fund is the most common solution. Money is collected from electricity consumers as part of their electric bill and deposited in a trust fund (NEI 2015).

Approximately 20% of the electricity production in the United States is covered by nuclear.

The last nuclear reactor, Watts Bar 2 in Tennessee, started commercial operation in October 2016.

#### SYSTEMS FOR PAYMENT TO THE FUNDS

In 1982, the US Congress passed the Nuclear Waste Policy Act directing the Department of Energy to build and operate a repository for used nuclear fuel and other high-level radioactive waste. The act set a deadline of 1998 for the Energy Department to begin moving used fuel from nuclear energy facilities (NEI undated web page). To fund the federal nuclear waste program, the Nuclear Waste Policy Act established a Nuclear Waste Fund. Since 1983, electricity consumers have paid into the fund 0,10 cent per kilowatt-hour of electricity produced at nuclear power plants. The payment to the Nuclear Waste Fund discontinued in 2014, after nuclear industry filed a lawsuit to end the collection due to the termination of the Yucca mountain repository programme in 2010.

The amount paid per kWh is about equal to the amount being paid to the Swedish waste fund, 0.11 Euro cents. The amount paid to the Swedish fund has been assessed as being inadequate to pay for decommissioning and handling

of the nuclear waste, and a government committee in Sweden has proposed to increase the amount paid by 3 to 5 times to secure sufficient funds for the tasks ahead. The situation in Sweden is probably not unique among the nations with a large nuclear industry. It should be noted, however, that the Swedish fund should cover more than the US fund; Sweden has decommissioning and nuclear waste in one fund. Still, the question remains if the funds accumulated in the US nuclear waste funds, both the federal fund and the private funds set aside by each operator, will be sufficient. This is worsened by the fact that any solution seems far away, contrary to Sweden where they have advanced further.

At the same time, funds for decommissioning continue to be set aside. There is no big fund like there is for waste, and no central decision on how much money to be set aside. Rather, each licensee decides how much they set aside. The nuclear regulator NRC has responsibility to control that licensees are on track with collecting money. Licensees use a “decommissioning funding formula” developed by NRC to estimate decommissioning costs for its facility, and accumulate money accordingly. Closer to decommissioning, the licensee makes a preliminary decommissioning cost estimate 5 years before the reactor’s projected permanent shutdown, and then a site-specific cost-estimate prior to or within 2 years following shutdown. Then, toward the end of decommissioning licensees submit a license termination plan with updated site-specific cost-estimate (GAO 2012:8-9).

The formula estimates decommissioning costs by reactor type and capacity to generate electricity, and is based on studies published in 1978 and 1980. The three cost factors identified in the formula is labour, energy and low-level radioactive waste disposal (GAO 2012:6). The United States Government Accountability Office (GAO) has shown that the “decommissioning funding formula”, may be outdated. The GAO compared NRC formula-generated cost estimates with licensee-generated site-specific cost estimates for 12 reactors and found that for five of these, the NRC formula captured 57-76 % of the costs reflected in each reactor’s site-specific estimate. The other seven captured 84 to 103 percent (GAO 2012:13).





Vermont Yankee NPP. (Photo: Kjersti Album)

#### HOW THE FUNDS ARE MANAGED

The Nuclear Waste Fund accumulates at a rate of USD 750 million a year, and the fund accrues more than USD 1 billion in interest each year. According to Forrest (2015:271), the amount in the fund is USD 30 billion. In the audit report for 2014 from the US Department of Energy, the numbers are given for cumulative revenue from fees and the accumulation of funding for a separate defence-generated nuclear waste fund at USD 25,4 billion as of September 30, 2014. Cumulative interest earnings and other revenue totalled approximately USD 22,0 billion. Total spending authorized by the government is approximately USD 11,4 billion. What is left in the fund is then  $(25,4 + 22,0) - 11 = 36,4$  billion. Of this sum a part is earmarked for defence-generated waste, so around USD 30 billion for the civilian nuclear industry seems about right.

Licensees choose how their decommissioning money is to be managed. But if they choose to invest their trust funds they are required to do so in accordance with standards set by the NRC.

For reactors that are owned by public utilities –about half of the reactors– investments are regulated by several standards set by Federal Energy Regulatory Commission (FERC). For instance, the fund must be independent from the public utility, its subsidiaries, affiliates or associates and the public utility may not serve as its own investment fund manager. Also, public utilities must submit annual decommission fund statements to FERC (GAO 2012:9-10).

For reactors that are not owned by public utilities, NRC standards state, among other things, that the funds must be held by an independent trustee and investments may not be made in any reactor licensee or in a mutual fund in which 50 percent or more is invested in the nuclear power industry, and no more than 10 percent of the funds can be indirectly invested in securities of any entity owning or operating a reactor (ibid:10).



## HOW THE MONEY IS USED

In 2010, Nuclear Industry organizations filed a lawsuit in response to the termination of the Yucca Mountain repository program, challenging the Department of Energy's continued collection of the nuclear waste fee to pay for a non-existent used nuclear fuel management program (NEI 2014). "Without a high-level radioactive waste management program and annual congressional appropriations, these funds are not available for their intended purpose", explained the industry at the NEI webpage and celebrated that the fund collection stops by this infographic (Illustration: nuclear industry infographics from www.nei.org).

The decommission fund money collected by each licensee is used for decommissioning of the reactor in question. Included is also the treatment and storage of low-level radioactive waste (GAO 2012: 5). However, spent nuclear fuel management does not fall within the scope of NRC's definition of decommissioning or under NRC's decommissioning oversight authority, and licensees must pay for these costs with funds that are separate from their decommission funds. The same goes for other post-shutdown activities such as site restoration which includes clean-up of non-radiological contaminants (GAO 2012:5).

Licensees are responsible for management of spent nuclear fuel until it can be transferred to the Department of Energy, which is responsible for providing permanent disposal. As noted above, the Department of Energy has so far failed to provide a management programme. Thus, without access to a permanent repository fit this waste, licensees may need to store the fuel on-site (GAO 2012:5).

Herein lays a momentous challenge: Licensees are responsible for storing the spent nuclear fuel until it can be transferred to the Department of Energy, and with the termination of Yucca Mountain repository programme, licensees are required to wait a long time for such a transfer. Costs for construction and demolition of on-site storage facilities for spent nuclear fuel are not included in decommissioning. The reasonable short-term solution is that the money licensees no longer pay into the nuclear waste fund, instead are used for construction and operation of

on-site storage, in addition to saving money for demolition of these storages when the spent fuel can be transferred to the Department of Energy in the future.

An important criterion for a well-functioning decommissioning process is full transparency in the use of the funds set aside for decommissioning of nuclear reactors. As we have seen, there is pressure from the owners of nuclear reactors to use funds from the decommission funds to pay for the construction of temporary storage facilities for spent nuclear fuel on the reactor site, in wait for a final storage solution. This is not part of the decommissioning process and should not be paid from the trust funds. It is therefore necessary to monitor the use of the trust funds closely to avoid it being used for purposes other than the decommissioning of the nuclear reactor.

It should also be noted that "These nuclear decommissioning trust funds are not the property of the electric utility. They are outside the electric utility's control. In bankruptcy situations, for example, decommissioning trust funds cannot be used to satisfy creditors' claims" (NEI 2015).

In a comment to the decommissioning of Vermont Yankee nuclear power plant, it was pointed out that the transparency of the use of the decommissioning funds set aside by publicly owned nuclear reactors in the US, are ensured because there are strict oversight rules and financial controls in place. These can be applied through public service commissions and boards to monitor decommissioning trust funds and the decommissioning process (Fairewinds 2015).

Since the absolute majority of power producing nuclear reactors are owned by or created as a public utility, the strict oversight rules and financial controls are therefore in place for the majority of the reactors. However, the same report indicated that while the NRC – Nuclear Regulatory Commission – approved the concept of privately owned, commercial nuclear reactors not owned by the public, it seems not to have developed such financial oversight methodology for reactors with this kind of ownership (Fairewinds 2015).

## 5.2 SWEDEN

The Swedish Nuclear Waste Fund was started in 1982, 10 years after the first commercial nuclear power reactor started up in 1972 (Oskarshamn 1). In 1977 the parliament passed the Nuclear Stipulation Act (in Swedish villkorslagen), stating that no new reactors would get permission to load and operate without showing that the nuclear waste could be safely taken care of (Johansson & Steen 1981: ix). The nuclear industry joined in establishing SKB, Svensk Kärnbränslehantering AB, with the task to take care of the Swedish nuclear waste.

Sweden currently has 10 commercial reactors at 3 nuclear power plants; 3 in Forsmark, 3 in Oskarshamn and 4 in Ringhals. The reactors at Barsebäck, close to Denmark's capital Copenhagen, have been closed and are currently awaiting dismantlement. A decision to close down has been made for 3 more reactors, including Oskarshamn 1 which will be closed already in summer 2017. In 2016, the Swedish nuclear power production amounted to 35% of the electricity production.

### SYSTEM FOR PAYMENT TO THE FUND

In the early 1980s the Swedish parliament devised a system for financing the costs for safe future management and disposal of the spent nuclear fuel, and decommissioning of the nuclear power stations. Under this system, the owner or operator of a nuclear facility pays a special fee to the Swedish state. The government decides the size of the fee, based on recommendations by the Swedish Radiation Safety Authority. The fee is given as a rate per kWh of electricity delivered by the nuclear power plants. Since 2008 the fee can also be determined as an amount in Swedish kronor, to be paid by a licensee who no longer delivers nuclear energy (Kärnavfallsfonden 2015:5). The fee is differentiated for each fee payer and is calculated so that the total fees for each payer cover that particular payer's total costs (Kärnavfallsfonden 2015:7, kärnavfallsfonden undated: section "Fee payments and disbursements").

Each nuclear power company and other fee-liable licensee is fully responsible for all its costs, even if the feed accumulated in the Fund should not be sufficient (ibid:5). However, if it is

turns out that a reactor owner cannot pay, and the Fund is insufficient, the state will in the end have to contribute the necessary funds. Therefore, the state is entitled to charge the nuclear power companies a risk fee for this risk, but so far the government has not decided on such a risk fee (ibid:5).

The paid-in fees are earmarked for each payer and may only be used to cover the costs attributable to that particular payer. In fact, if there is a surplus after all costs have been paid, these surplus fees must be paid back to the payer (ibid: page 7).

### HOW THE FUNDS ARE MANAGED

In the beginning in 1982 and until 1996, the fees were deposited in an interest-bearing account at the Swedish central bank. In 1996 the current management model was introduced (kärnavfallsfonden 2015:6). In the beginning, investment options were restricted, but in 2002 the rules were changed to open for investment in treasury funds and in 2009 the rules were changed again to permit investments in covered bonds as well (ibid:9). The board adopts investment policy each year. The current investment strategy is posted at [www.karnavfallsfonden.se](http://www.karnavfallsfonden.se), providing an example of Swedish transparency.

The Nuclear Waste Fund has a board of governors, but no employed staff. Kammarkollegiet performs administrative services for the fund, including capital management. Kammarkollegiet is the Legal, Financial and Administrative Services Agency, a Swedish administrative authority under the Ministry of Finance.

So far, the fund has been obliged to invest primarily in Swedish government bonds. The interest from the investments has been accumulated in the fund. The low long-term interest rate for this type of investment for the past decades has meant that the accumulation of money in the fund has decreased. The fund might therefore lack between 3 and 5 billion Euros as a result. The Swedish government asked the regulator of the fund to investigate a way to reduce the risk the state will take if it must pay for the industry's costs in the future. The regulator, assisted by several other government institutions made an initial assessment that the fee paid by the nuclear power companies should be raised

from the present 0.22 Euro cent to between 0.66 Euro cents and 1.1 Euro cents per kWh, e.g. between three and five times the present level (Kåberger and Swahn 2015:222).

This strategy would not necessarily work, according to Kåberger and Swahn. The reason is that the average production cost for electricity from some nuclear power plants is already higher than electricity prices in the future market for the next ten years. If the nuclear reactors must close because of the increased fee, there will not be any income for the waste management fund.

To avoid this, the regulator has proposed three new ways of solving this problem. One is to assume a longer lifetime of the reactors and the time of fee-paying. The second is a proposal that the fund should be allowed to invest in shares and other riskier financial investments, as this could yield a higher rate of return. According to the third solution, the rate of return should be expected to increase in the future, despite that this is highly unlikely. None of these proposals are without risks, as all of them could be overturned by events outside the regulator's and the fund's control. Reactors may have to close prematurely, the investment in shares may in a financial crisis lead to great losses, and the long-term interest rate on bonds and traditionally more secure investments may turn out to remain low for decades.

From the description of the general risks to the accumulation of funds above, it is clear that all reactors are in the danger of not having enough funds for the decommissioning, as well as for the handling of the radioactive waste and spent nuclear fuel. According to Kåberger and Swahn, the decommissioning fund in total may lack between 3 and 5 billion Euros (ibid:222). If several reactors should be stopped and their decommissioning process begun at the same time, the lack of funds may get acute. As long as this does not happen, the real situation may be hidden from the public eye for many years to come. If nothing is done to correct the situation, this would in case make the situation worse, as the deficit in the fund will only get bigger as time goes by.

In addition, some of the reactors may have to close prematurely because of unforeseen

technical problems, or shut down because of political choices. In the case of the early closing of reactors, the risk of not having enough funds for the decommissioning of individual nuclear reactor increases manifold. This is because they will no longer bring new revenue from the sale of electricity to their decommissioning fund. Both the owners and to some extent the state will therefore have an interest in not bringing about an early closure. An increase of the fees according to the assessment cited above by 3 times or up to 5 times compared to the present level could cause an early closure. As we see, the state may find itself in a difficult situation: a decision to close a nuclear reactor for safety reasons can cause a huge increase in the state's economic burden, because the lacking funds will have to be paid by government instead. This dilemma may not be particular to Sweden, but as Kåberger and Swahn write, the transparency of the situation in Sweden is beneficial in the long run. This increases the ability of Swedish society to discuss the problems and hopefully come up with a solution to the funding of the decommissioning and handling of radioactive waste and spent nuclear fuel. Increased transparency about the decommissioning funds may therefore also be a recommendation to take away from the Swedish experience and applied to other countries.

#### HOW THE MONEY IS USED

The nuclear waste fee is used to cover all the licensees' costs related to safe management and disposal of waste products and decommissioning and dismantling. Also, it is used to cover the state's costs for supervision and examination of questions regarding these questions. Also, costs for information to the public, both for licensees, state and municipalities are covered. Costs for support to non-profit organisations (NGOs) for their efforts concerning siting of facilities for management and disposal of spent nuclear fuel are also covered by the fund. (Kärnavfallsfonden 2015:8). Joint costs, such as regulatory costs, are allocated among the fee-liable licensees (ibid: page 8).

### 5.3 GERMANY

Germany has considerable experience in decommissioning of nuclear power plants. 16 nuclear

power plants are currently at different stages of decommissioning and three decommissioning projects have been completed (IAEA 2016).

After the accident of the Fukushima nuclear power plant in Japan in 2011 the parliament / Bundestag decided to shut down the country's nuclear power plants in 2022 as part of its *Energiewende* (energy transition). This was the plan already in 2002, but was reversed under Angela Merkel in 2010 when she extended the operation time. The eight oldest plants were shut down in August 2011 following the Fukushima disaster. Eight commercial nuclear power plants are still in operation. Germany is therefore in the situation that part of the income to the decommissioning fund and handling of nuclear waste has already been stopped. This places a greater economic strain on the remaining reactors, as well as on the federal government.

In Germany, the share of power production from nuclear power plants in 2015 was 14 per cent, a decline compared to 2000 when the share was 29,5 per cent (AG Energiebilanzen 2016).

#### SYSTEMS FOR PAYMENT TO THE FUNDS

The way funds are set aside for financing decommissioning activities differs between publicly-owned nuclear plants, nuclear plants with mixed ownership, and nuclear plants belonging to private companies.

In general, decommissioning of publicly owned nuclear facilities is financed from the current budget. The state pays the decommissioning for *Energiewerke Nord GmbH* (EWN) activities in former East Germany, since these power plants did not find private owners after Germany's reunification. Here it should be noted that *Energiewerke Nord*, situated in Greifswald, had Soviet designed reactors of the same type as Kola nuclear power plant. The plant was successfully decommissioned using a strategy of immediate dismantling.

EWN is a company 100% owned by the German state since 1 January 2000 (Wuppertal 2007a: 14). The environment ministry estimates a bill of around 6 billion euros for these decommissioning works excluding the costs for finding, building and operating a final repository but

says the figure is "afflicted with great uncertainties" (Clean Energy Wire 2015a).

For facilities with mixed ownership, there are special arrangements needed to clarify how much of the costs the public and how much the private organisations should contribute with.

Following the "Polluter Pays Principle", the licensees have been responsible for any decommissioning activities, and they have had to bear the respective costs. They have also been free to decide on the decommissioning strategy they would like to follow. The private owners of nuclear facilities build up internal unrestricted funds according to German commercial law (*Handelsgesetzbuch*). The decommissioning financing regime is determined by the Atomic Energy Act (*Atomgesetz*). The obligation to set up provisions starts at the beginning of operation, as follows: Provisions for spent fuel management are allocated according to their burn-up over the period they are used in the reactor (about 4-5 years). Provisions for the management of the core are allocated over the first 19 years of operation. As long as the final shut down of a nuclear facility was not exactly determined, provisions for dismantling, decontamination and demolition have to be accumulated in equal instalments over the first 25 years of operation. The respective cost estimates on which the provisions are based are regularly checked by the fiscal authorities of the state ("Länder") ministries. However, the possibilities by the fiscal auditors to really control the economic and technical basis for the values determined are limited (Wuppertal 2007a: 27-30).

By the end of 2014, the four big German utilities E.ON, RWE, Vattenfall and EnBW had set aside 38 billion euros, 22 billion for decommissioning their power plants and 16 billion for final storage (Clean Energy Wire 2015a).

There have been several proposals to install a governed external decommissioning fund and now it is happening. An independent commission – The commission to review financing for the nuclear energy phase-out (*Kommission zur Überprüfung des Kernenergieausstiegs*) - was set up in October 2015 by the German government. Its mandate was to develop recommendations for action, such as ensuring the financing of the decommissioning of the country's reactors and

the disposal of radioactive waste can be secured so that the utilities involved are financially able in the long term to fulfil their obligations.

The commission presented its recommendations to the Ministry of Economic Affairs and Energy in April 2016 and as a result the German cabinet in October 2016 adopted a draft bill based on the KFK's recommendations and finalized a deal with nuclear power plant operators E.ON, EnBW, RWE, and Vattenfall over long-term nuclear waste disposal. Under the agreement, the four operators are freed of responsibility for storing radioactive waste – that responsibility is instead transferred to the state. In return, the operators will pay a total of 17.4 billion euro into a state-administered fund to finance the interim and final storage of nuclear waste. They will also pay an additional «risk surcharge» of 6.2 billion euro (35.5%) to cover the eventuality that costs exceed current projections and that the return on capital in the fund could be lower than expected. The operators will be responsible for decommissioning and deconstructing their own nuclear power plants, as well as preparing their radioactive waste for final storage. The draft law is due to be enacted in early 2017. Critics claim the total of 23.6 billion euro would prove insufficient and that future taxpayers will carry the risk. “With the draft in its current form, the polluter pays principle was invalidated and the taxpayer would now have to bear «enormous financial risks», said Hubert Weiger, head of BUND, Friends of the Earth Germany (Clean Energy Wire 2016).

#### HOW THE FUNDS ARE MANAGED

The new state-administered fund will be controlled by a board of trustees comprising representatives of the economy, finance and environment ministries, which is responsible for the safe investment of the funds for decades to come.

There has not been any request for the operators to disclose information on their reasons for choosing a specific decommissioning strategy, or on decommissioning costs or financing as long as the authorities are convinced that the operator is a reliable entity according to the regulations of the Atomic Energy Act. Basic company-specific but not plant-specific information on provisions accumulated is given in financial

reports of operators and their mother companies (Wuppertal 2007a: 44).

#### HOW THE MONEY IS USED

Each decommissioning project is unique. The course of the project, its financing, the choice of decommissioning strategy and many other conditions depend on the type of facility and its owner.

The legal framework for the decommissioning of nuclear facilities stipulates that decommissioning is subject to licensing by the competent authority. There are two different strategies allowed: either immediate dismantling or dismantling after safe enclosure. The decision as to which decommissioning strategy to implement is taken by the operator. Most operators have opted for dismantling immediately. The commission to review the financing for the phase-out of nuclear energy (KFK) recommends discarding the previous option between safe enclosures and immediate dismantling, and instead making immediate dismantling mandatory. Additionally, the Federal Government and the Länder should ensure that approvals for decommissioning and dismantling are granted more quickly and efficiently.

Estimating the costs for the nuclear clean-up is notoriously difficult, because it will likely last until the next century. Just finding, constructing and operating a final repository for highly radioactive waste could come in at anywhere between 10 and 70 billion euros. Decommissioning and dismantling nuclear power plants are estimated to add between 26 and 67 billion euros to the bill. The environment ministry expects the cost burden to peak between 2016 and 2020 but says storage will still need financing in 2080 (Clean Energy Wire 2015a).

Figure 2 shows the share of different costs for nuclear decommissioning and storage to be covered by the state and/or utilities, amounting to over 65 billion euros, according to current environment ministry estimates (Clean Energy Wire 2015b).

Figure 3 shows the time line for expenses of private companies for the nuclear clean-up, excluding costs for final storage, giving a total sum 34 billion euros (Clean Energy Wire 2015b).

FIGURE 2: SHARE OF COSTS FOR NUCLEAR DECOMMISSIONING AND STORAGE

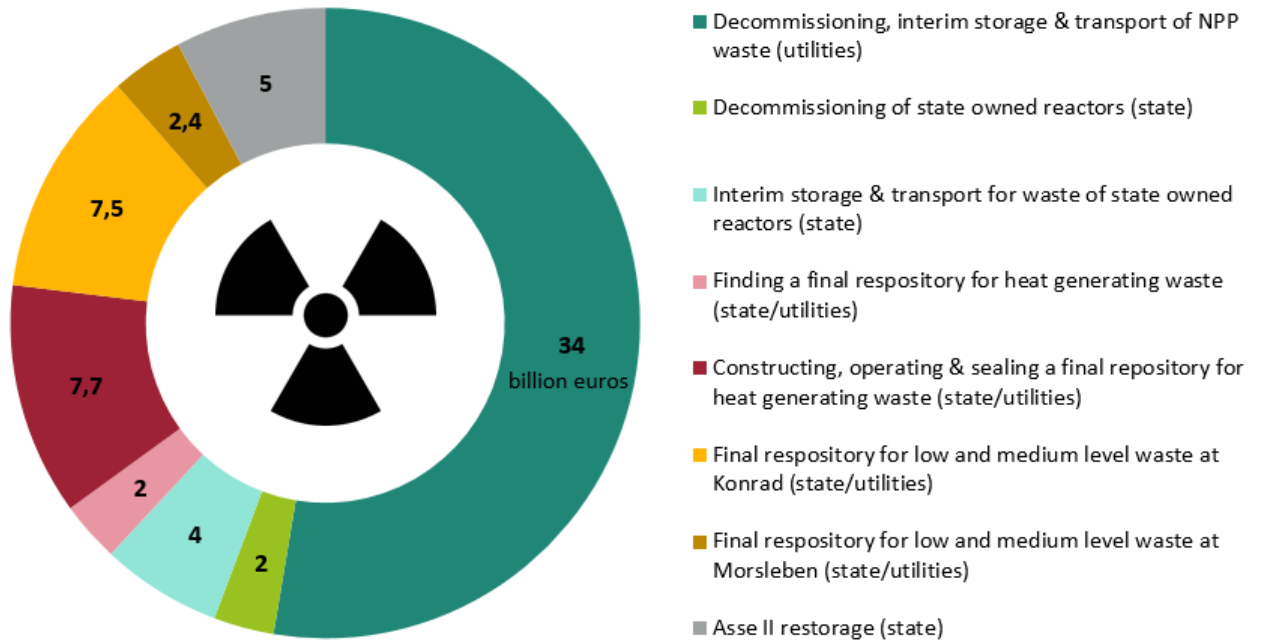
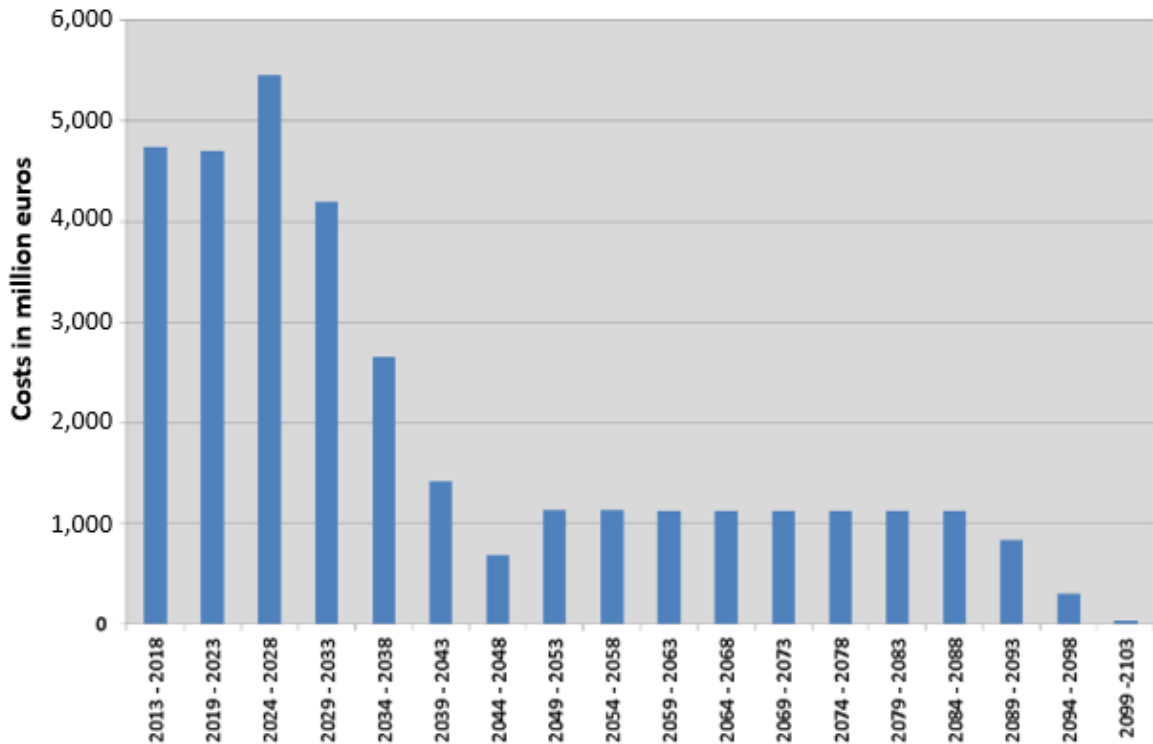


FIGURE 3: TIME LINE FOR EXPENSES



## 5.4 RUSSIA

In 2006, our network of non-governmental environmental organisations published a report on Russia's decommissioning fund (Decommission Network 2006). The report collected far more knowledge than what was publicly available before. Our method of repeatedly sending letters to the authorities, with more and more specific questions as the situation became clearer yielded credible results.

The main findings were that money was collected into a decommissioning reserve, 1,3 % of the gross income from the power sales. The reserve was common for all Russian nuclear power plants, and money was not linked to any actual reactor. The collection started only at the end of the planned operation time of the first generation, with little time to build up substantial capital. We also found that money from the reserve was spent on already closed reactors in Novovoronezh and Beloyarsk, which did not generate allocations to decommission themselves (ibid:14). The pessimistic conclusion was: too little, too late.

10 years later, the situation has improved. The regulation has been changed; now collection of funds has been changed from 1,3% previously to "up to 3,2%" of revenues and more money is put into the reserve annually. According to information from Rosatom, the funds accumulated in the decommission reserve was about RUB 10 billion in January 2015 (Rosatom letter 2015), which corresponds to approximately EUR 160 million. Rosatom also stated that in 2015, the plan was to allocate RUB 5.6 billion in 2015 (ibid.) This gives hope for a more responsible attitude to the process of decommissioning of old nuclear power units.

At the same time, reactors grow older and closer to their real closing time and it is less time for accumulating money for decommissioning. Although the collection of money for decommissioning has improved, it is still far from what is needed to decommission the Russian nuclear power reactors.

Russia has 35 nuclear reactors, of which 25 reactors operate on prolonged licence, more than their designed lifetime of 30 years. Five reactors are closed, but not yet decommissioned. Three reactors are under construction. The nu-

clear share of electricity production is 18-19 %.

### SYSTEMS FOR PAYMENT TO THE FUNDS

Article 34 of the federal law "On the Use of Atomic Energy" prescribes that decommissioning must be organized in the respective operating organization with other involved institutions. This is now part of the structure of the State Corporation «Rosatom».

Furthermore, Article 34 states that the operator must have adequate capacity, including financial, material and other resources to complete the task of decommissioning. The operator, in conjunction with other institutions responsible for the use of nuclear energy, and with the involvement of their budgetary resources, should create a fund to cover the costs associated with the decommissioning of nuclear facilities, radiation sources and storage facilities, as well as to fund research and technical experimental work aimed at ensuring the safety of nuclear facilities. This means that under the law of 1995, the financing of the decommissioning of nuclear power stations should be provided by the federal budget as well as other sources.

How much must be taken from the budget compared to the fund is not clear. The state program «Nuclear and radiation Safety 2008 – 2015» was approved by the Russian government July 13, 2007 (Decree number 444). The entire program received 129 billion rubles from the federal budget from 2008 to 2015 (FCP undated). Thus, money used each year from 2008 to 2015, is on average more than what is put into the fund in 2015. The total amount in the fund per January 2015, is also far below the amount in the program on nuclear and radiation safety.

The sources to the reserve are defined in Article 4. Six sources are defined; four of them are dedicated revenues from the federal and regional budgets. One is revenues from public and private sources. The last source is allocations from the operating organization, comparable to the other countries we described, and will be elaborated below.

Article 6 of the regulation states that no later than 3 years before the end of the life of the unit, its decommission program should be developed. The unit must be examined, and a special

commission must develop proposals for decommissioning and carrying out necessary works to improve its level of safety.

In Article 7, in addition to article 4, provides that in new power plants the income from the electricity shall be paid to the fund from the reactor's first day of work, and for existing facilities, these funds will supplement allocations from the budget.

According to a new government resolution in 2012, revenues from nuclear power production is to be collected for several purposes:

1) reserve to finance the costs for nuclear, radiation, technical and fire safety in the operation of nuclear power plants - not more than 10% of revenues;

2) another reserve to finance the costs of physical protection, accounting and control of nuclear materials at nuclear power plants - not more than 2% of revenues;

3) reserve to finance the costs to ensure the decommissioning of nuclear power plants and conduct research and development work to improve the safety of decommissioning facilities - not more than 3.2% of revenues;

4) reserve to finance the cost for development of nuclear power plants - here, the tariff, varies each year

5) reserve to finance the costs of ensuring the disposal of radioactive waste - not more than 1.5% of revenues.

The sub-paragraph 3 in the resolution is what can be considered the real decommission fund, and the percentage (3,2%) to be compared to other countries. As stated above, this reserve currently has RUB 10 billion for its purpose. Combining sub-paragraph 3 and 5, similar to Sweden, gives a total 4,7% of revenues for decommission and disposal of radioactive waste.

Of the countries presented in this report, only Russia has a system where the operator pays a percentage of revenues into the fund. In other countries, the cost is added to the electricity price.

It should also be noted that treatment and storage of spent nuclear fuel is not among the purposes which money is to be collected for, except temporary storage at site that is covered by point 2. Where other countries such as US and Sweden consider spent nuclear fuel as waste

that must be stored, Russia still considers spent fuel to be a resource and continue to believe in reprocessing for future use.

According to the experience of recent years, both Russia and other countries intend to extend the life of the oldest reactors to 30 years beyond the design lifetime, which means that the operation of the most reactors will be 60 years. Thus, they will continue to collect decommission money for a longer period. Still, as it looks today, the Soviet-constructed reactors will not collect enough money for their decommissioning. The current reserve, with its rules for funding and management, will be far from enough to pay for decommissioning. These costs will fall heavily on future generations of Russian taxpayers.

The concept of the fund as it is today, implies that as older reactors closes without having collected sufficient funds, it will be necessary to operate an increasing number of new nuclear power plants to raise sufficient funds for the final decommissioning of the old units. Budget funds are already used.

#### HOW THE FUNDS ARE MANAGED

The funds are managed by Rosatom. As shown above, money is not accumulating enough in the reserve. Collected money is to a large extent spent on already closed reactors, along with funds from the federal budget. As mentioned above, Russia has a government program to support decommissioning. According to Rosatom (2015), the program is effective.

To ensure the real accumulation of resources for the decommissioning of old Russian nuclear power requires that the decommissioning fund is managed independently from the operating organization.

The accumulation and disbursement of the fund should be transparent to the public and include possibility of the participation of relevant stakeholders. Also, there should be separate allocation of funds for each nuclear station.

#### HOW THE MONEY IS USED

Money from the decommission reserve is still spent on reactors which were closed before the collection started, but we do not know how much that is each year, or following what plans. Rosatom states in the above-mentioned letter



(Rosatom letter 2015) that in the next decade, it is planned to spend money from the decommissioning reserve on decommissioning of units 1 and 2 of Beloyarsk NPP, unit 1-4 of Bilibino NPP, unit 1-3 of Novovoronezh NPP, and unit 1 and 2 of Leningrad NPP. They further confirmed that decommissioning of Kola NPP is not planned, as the facility is earmarked for an extension of its designed lifetime. Rosatom also reiterated that talking of the cost of works on decommissioning reactors, is premature (ibid.).

We don't know the costs of decommissioning for the Russian nuclear power reactors, as comprehensive and detailed decommissioning plans are still missing. Thus, it remains unclear whether the funds that are accumulated will be enough for a safe decommissioning. Moreover, the use of budget funds clearly indicates that there is not enough money collected. The situation being as it is, using money from the budget for decommissioning old reactors seems like a good alternative solution.

We agree that Rosatom's decommissioning program definitely has some positive impact, such as decommissioning of nuclear reactors 1 and 2 of Novovoronezh NPP, Beloyarsk 1 and 2 etc, but a big challenge is lack of information. On the official web-site of the program (FCP undated) there is only common generalized information provided without description of specific activities and costs, making it difficult to analyse the result and issue public control of the program.

It should be noted that this program contains a huge variety of measures, altogether. The program covers construction of a centre for the processing of spent nuclear fuel in Krasnoyarsk, export of nuclear sources of Antarctica and the

North Pole, liquidation of old military storage facilities for radioactive waste, as well as decommissioning of nuclear reactors 1 and 2 of Novovoronezh NPP, Beloyarsk 1 and 2 nuclear power plants, military reactors in Zheleznogorsk and Seversk, construction of storages for radioactive waste etc.

Also, although there is a federal programme for storage of radioactive wastes, plans for the construction of regional storages have been rejected in some regions of Russia (in Kalmykia and Komi), and several of the locations are not clarified. In addition, there is a plan for constructing another big storage for high level of radioactive waste for the whole Russia, in Krasnoyarsk.

On the one hand, we can assume that in Russia decommissioning may not be as costly as in Western Europe, USA and Japan. Firstly, Russia has lower labor cost and material costs than other countries, which will affect the total cost. Secondly, the situation with the presence of vacant land in Russia is not as intense as in Western Europe, and especially in Japan. This means that there is no urgent need for a rapid return of the site to a state of «green lawn».

On the other hand, since Russia lacks sufficient unemployment benefits, it could be argued that the decommissioning budget should also include money for retraining and a just transition of jobs, in addition nuclear mono-towns, nuclear facilities have provided a higher living quality, not just high paid jobs but also additional funding for swimming pools, cultural schools etc. These arguments could mean that decommissioning could in fact altogether be more expensive in Russia than in for instance Sweden.



## 6. COMPARISON OF SOLUTIONS

In previous chapters, we have presented different criteria for funding systems. We have also presented the solutions chosen in the different countries. In this chapter, we will compare the solutions, and evaluate them.

In table 2 we present an assessment of the systems in Germany, USA, Sweden and Russia, using the five criteria stated in our Concept of a Decommission plan for old nuclear power reactors (Decommission Network 2008:28). It should be noted that the scope here is what can be of interest in order to improve the current decommissioning situation in Russia. We have

therefore chosen to include Russia in the table, to show the differences and similarities with the other countries.

The first criterion has been divided in two, as it in reality is comprised of two different concepts. The first part argues that “Each NPP should run its own decommissioning fund”, here the meaning can be summed-up as individuality. The second part posits that the fund should be “sufficient for solving the whole complex of related problems”, here the point is not the individuality itself, but that funds should be enough to solve the whole complex of related problems.

**Table 2: Comparing systems in Sweden, USA, Germany and Russia**

	Sweden	USA	Germany	Russia
<b>1a) Individuality.</b> Each NPP should run its own decommissioning fund	The fund, Kärnavfallsfonden, is common to all licensees and reactors, but money is earmarked so that a surplus is to be paid back even if another licensee has paid too little.	Each licensee runs its own decommissioning fund, or has alternative solutions to provide reasonable assurance that they will accumulate adequate funds for decommissioning.	The operators is responsible for decommissioning and deconstructing their own nuclear power plants, as well as preparing their radioactive waste for final storage and must build up internal unrestricted funds according to German commercial law.	There is a common fund for all reactors.  The fund is managed by the state cooperation Rosatom. All NPPs have the same operator; Rosenergoatom which is owned by Atomenergoprom, a part of Rosatom state corporation.
<b>1b)</b> Sufficient for solving the whole complex of related problems.	There has been raised concern that funds are not sufficient and estimated between 5 and 6 billion Euros are missing.  The fund also covers for instance NGO work in relation to nuclear waste issues, which is a rather broad definition of "whole complex of related problems".	The Government Accountability Office has raised concerns if the assurance from licensees is reliable.  Handling of spent nuclear fuel is not considered part of decommissioning, but as the government programme for disposal site has stopped, spent fuel will need to be stored on-site, and licensees cannot use their decommissioning money to pay for these costs.	A state-administered fund to finance the interim and final storage of nuclear waste is to be enacted from 2017. The operators will pay a total of €23.6 billion to the fund.	The industry has not proven that the collected amounts will be sufficient to cover what is needed.  On the contrary, state programs based on federal budget resources are used to fund necessary work on decommissioning.
<b>2) Transparency.</b> Fund expenditures on the power unit decommissioning should be published and kept under public control.	Sweden has the most transparent system, on all aspects of the fund and its spending.  Kärnavfallsfonden publishes annual reports easily accessible on their web site, in both Swedish and English languages.	Transparency of the use of decommissioning funds ensured by the strict oversight rules and financial controls applied through public service commissions and boards.	The internal funds are examined and adapted annually and checked by independent auditors, but are criticized for lacking transparency.  This will be better with the new government fund.	Transparency has improved, but is still not satisfactory.
<b>3) Self-repayment.</b> Means of the fund come from	Yes, everyone pays for their own reactor, except for some small reactors such as old research reactor in Studsvik,	Yes, every licensee guarantee the decommissioning funding for his reactor.	Yes, strict rules ensure that the cost of dismantling the reactor core should be set aside during the first 25 years of operation.	No, funding also comes from regional and federal budgets.

<p>the transferred percentage of the revenues from electricity sold and other financial activities of the decommissioned NPP.</p>	<p>where a small percentage is taken from the others.</p>	<p>However, the formula for estimating the cost of decommissioning may be outdated, and does not give the real cost of decommissioning. Regulations are not necessarily making the owners pay for the whole cost decommissioning. NRC is said to be granting too many exceptions to the rules, allowing the owners to make the public pay for parts of the process.</p>	<p>So far, budget funds pay most of the costs and a smaller part comes from the revenues or other financial activities of the NPPs.</p>
<p><b>4) Independence of Fund management from the operating utility.</b> The fund should be managed by one of the federal ministries and controlled by the Board of Trustees which has federal, regional and municipal representatives.</p>	<p>Yes, the nuclear waste fund is a government authority and has a Board of Governors. The board members are not representatives from local, regional or state structures, but rather industry related and/or knowledgeable in economy etc.</p>	<p>Yes, independence ensured for all public utility-owned nuclear reactors.</p>	<p>Not today, but the new state-fund will be independent from the operating utility.</p> <p>No, the fund is part of Rosatom state corporation. Rosatom owns all civil nuclear power plants through its holding company Atomenergoprom, of which the operator Rosenergoatom is the subsidiary.</p>
<p><b>5) Strict compliance with the Decommission plan should be observed.</b></p>	<p>The responsibility for the decommissioning is regulated according to the Polluter Pays Principle.</p> <p>The estimated lack of 3 – 5 billion Euros in decommissioning funds is not in strict compliance with the decommissioning plan.</p>	<p>Licenses use a “decommissioning formula” developed by NRC to estimate decommission costs for its facility, and accumulate money accordingly. Closer to decommission, the licensee makes a preliminary decommission cost estimate 5 years before the reactor’s projected permanent shutdown, and then a site-specific cost-estimate prior to or within 2 years following shutdown. Then, toward the end of decommissioning licensees submit a</p>	<p>The Polluter Pays Principle also underpins the German handling of decommissioning and waste management. A new government fund is starting to function in 2017, into which the owners of nuclear power plants have paid a total of EUR 23.6 billion. In return they will be free of responsibility for the long-term storage of high-level nuclear waste. Critics argue that the sum would prove insufficient</p> <p>Article 34 of the federal law “On the Use of Atomic Energy” states that the operator must have adequate capacity, as well as financial, material and other resources to complete the task of decommissioning. The industry has not proven that it has the necessary funding to do so. Government funds must cover the gap. This is not in strict compliance with the decommissioning plan, as can be read from article 34.</p>

	<p>license termination plan with updated site-specific cost-estimate.</p> <p>The formula may be outdated according to critics, so the decommissioning may be short of funding when it starts. This is in case not in strict compliance with the decommissioning plan.</p>	<p>and that future taxpayers will carry the risk. Critics claim that with the draft in its current form, the polluter pays principle was invalidated and the taxpayer would now have to bear "enormous financial risks". This would in case not be in strict compliance with the decommissioning plan.</p>	<p>Article 6 of the regulation states that no later than 3 years before the end of the life of the unit, its decommission program should be developed. The unit must be examined, and a special commission must develop proposals for decommissioning and carrying out necessary works to improve its level of safety.</p>
<p><b>General remarks</b></p>	<p>The Swedish system for funding decommissioning and nuclear waste is the most transparent of the national systems considered in this report.</p> <p>This makes it easier to see that the funding is probably not sufficient to fund the decommissioning and nuclear waste produced by the nuclear industry. In this respect Sweden is not different from the other countries, it is only easier to notice and criticize because of the transparency</p>	<p>The funding for decommissioning and nuclear waste should be considered separately. The transparency for decommissioning funding is good, because of strict oversight rules and control organs. The funding is probably not adequate.</p> <p>Funding for handling of nuclear waste is a separate system. The federal collection of funds for waste has stopped because the plan for a final repository in Yucca mountain has been stopped. Funds should now be collected by each operator.</p>	<p>The funding for decommissioning and nuclear waste comes from budgets and from the operator's reserves. The collected money to the reserves are not enough to pay for decommissioning.</p> <p>The reserves are controlled by Rosatom and the lack of transparency and openness can be criticized.</p> <p>Nevertheless, we have seen improvements during the last 10 years, and more money is now collected from the operator.</p>



At Ignalina power plant undergoing decommissioning. Study tour organized by Lithuanian and Russian NGOs, with participants from Russian nuclear industry and municipalities with nuclear industry. (Photo: Gennady Shabarin)

## 7. LEARNING POINTS

The most obvious learning point, which is valid for all countries, is that collecting money should have started earlier and/or more money should have been set aside. None of the countries are sure to have enough money for decommissioning and waste handling. However, Russia seems to be the country where collected money is furthest away from what is needed. Since we lack information about the real decommissioning costs and don't have complete overview over the current funds, we cannot say how much money is lacking. Russia "solves" this by using budget funds. Extending lifetime of old reactors – however problematic for safety and environment concerns – also postpones decommissioning costs, and gives somewhat more time for the collection of funds.

Lack of collected funds may pose a barrier for closing down nuclear operations. It should also be noted that failure to collect enough funds to cover decommissioning and waste, is in fact subsidizing nuclear power. However, when reality strikes and funding is scarce, we agree that money from the state budget should be used to pay for decommissioning and waste handling. It is at least better than postponing the necessary work.

The collection of funding for decommissioning and handling of nuclear waste can in principle be done either by collecting fees from the nuclear operators, usually by putting a fee on every kWh electricity sold. Or the net income from the nuclear reactors can be taxed, and the funds for decommissioning and handling of waste

can be set aside each year from the government budgets. Both methods have advantages and disadvantages. A fee on every kWh of electricity can ensure that the funding will accumulate independently of the economic situation of the country or region.

One particularly positive aspect of the German regulation of the decommissioning costs for reactors is the regulation requiring that the money for decommissioning of a reactor must be collected during the first 25 years of operation. This increases the chances that there will be enough funding for decommissioning of the reactor when it is finally stopped, even if it is closed for political reasons, for economic reasons or after an accident. On the other hand, there are no 100 % guarantees that funding will be diverted to other tasks. A transparent handling of the funding and strong institutions overseeing the management of the funds is necessary to counter any attempts to divert the funds from its intended purposes: the decommissioning of reactors and the handling of nuclear waste.

In Russia, the decommissioning and the treatment of spent nuclear fuel and radioactive waste are treated separately, similar to in the United States. In Russia, decommissioning money is collected in a similar way as nuclear waste money was in the US until 2014, as a part of the electricity price.

However, in the US money is paid as an addition to the electricity price, from the consumer and to the company, which again pays into the

nuclear waste funds. Money for decommissioning is still collected, but by the individual owners for each nuclear reactor. In Russia, the money to the fund comes from the gross income as a percentage, not as an addition to the price paid by the consumer. The money collected by the nuclear company through the electricity sales makes the gross income (vyrochki), from which the decommission money is taken. Moreover, Russia takes decommission money from federal and regional budgets, in addition to money collected from the operator.

Other important lessons learned from the different countries studied are diverse. From Sweden, the most important lesson for other countries, is the importance of transparency in the handling of the collected funds for decommissioning and handling of nuclear waste. There is probably not enough money in the government decommissioning fund for a simultaneous decommissioning of all remaining nuclear reactors in Sweden. An increase of the fee per kWh electricity produced by the remaining reactors by three to five times the present level will be necessary to collect enough funds. However, this will increase the price of electricity, and could lead to a closure of several nuclear reactors, as nuclear reactors cannot compete with cheaper sources of electricity when the real costs are included.

The situation in Sweden is an illustration of

the problems most governments in countries with nuclear reactors are facing. They depend on the continued generation of electricity from existing nuclear reactors to finance the decommissioning of the same reactors. Sweden is in a difficult situation, and it has not reached the necessary decisions to solve it. But, it has at least revealed what the real situation is. This kind of transparency is necessary for a political debate about how to provide the funding for decommissioning.

As shown in the US chapter, the collection of funds for a central federal fund for final storage of high level nuclear waste in the Yucca Mountain in Nevada was well under way, but was stopped in 2008. Consequently, in 2014 the federal government was not allowed to collect a fee from the electricity produced by the nuclear reactors any more. This situation has not been solved, and it is not likely to be resolved soon. This shows that there are no perfect solutions. It could be tempting not to allow for openness and participation and take a strong stand, simply pushing decisions through no matter the arguments against. However, also here lessons can be learned from Sweden in their work to locate waste repository; in bringing communities on board and ask them for their approval along the way, Sweden has found sustainable solutions based on relevant knowledge.



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■ **NATURVERNFORBUNDET** is the oldest environmental and nature protection organization in Norway. Naturvernforbundet is membership based and democratic, and consists of over 22,000 members in about 100 local groups across the country, working to solve environmental issues both local and global.

■ Our main goal is to protect nature and the environment so that human activity does not exceed the tolerance limits of our planet. We are concerned with a wide range of issues in environmental and nature conservation, but work specifically with the areas conservation, climate change, energy and transportation.

■ Although we have a national agenda, many environmental questions have proven to have an international or even global character. Issues concerning development, resource allocations and international cooperation are very much part of our everyday activities.

■ A member of Friends of the Earth International, Naturvernforbundet is part of the largest grassroots environmental network with more than 2 million members worldwide. Together we campaign the most urgent environmental and social issues.

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