Costs of Nuclear Power

Costs of decommissioning, radioactive waste disposal and nuclear accidents/liability - Experience of the JP NGOs

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Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW) (disclaimer: The content of this study does not necessarily coincide with the opinions of the BMLFUW – the BMLFUW supports the co-operation of NGOs within the Joint Project to improve transparency on nuclear issues)

The study at hand is based on the study "The true costs of nuclear power" commissioned by the Vienna Ombuds Office for Environmental Protection (Wiener Umweltanwaltschaft) published in 2013.

August 2014

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1 THE JOINT PROJECT GROUP

ABOUT US

The Joint Project is an ongoing co-operation of NGOs and research institutions on safe and sustainable energy issues with a focus on antinuclear activities in Central and Eastern Europe supported by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management.

Each year, a main topic of particular relevance for the anti-nuclear/sustainable energy work in Europe and some additional anti-nuclear topics are identified. The members work on these topics within:

- **one transnational Joint Project**
  which is co-ordinated by the Austrian Institute of Ecology (Österreichisches Ökologie-Institut), an Austrian independent research organization
- **national projects**
  which are coordinated by the Hungarian Environmental Partnership Foundation (HEPF). HEPF is a not-for-profit, politically independent organization promoting environmental improvement and awareness among civil society and the general public.

More information about our activities can be found under: **http://www.joint-project.org/**

MEMBERS OF THE WORKING GROUP

The joint working group consists of members from Austria, Bulgaria, Czech Republic, Hungary, Poland and Romania. Current members of the working group are:

Austrian Institute of Ecology (AT)	http://www.ecology.at/
Za Zemiata (BG)	http://www.zazemiata.org
Foundation for Environment and Agriculture – Agroecofund (BG)	
Calla (CZ)	http://www.calla.cz
South Bohemian Mothers (CZ)	http://www.jihoceskematky.cz
HEPF (HU)	http://okotars.hu/en
Energiaklub (HU)	http://www.energiaklub.hu
Common Earth (Wspólna Ziemia) (PL)	http://www.wspolnaziemia.org/?lg=&a=7
Terra Mileniul III (RO)	www.terramileniultrei.ro

2 INTRODUCTION – THE JOINT PROJECT 2013/2014 ON THE COSTS OF NUCLEAR POWER

European discussions about nuclear power are increasingly centred on the issue of costs: The costs for new-build are reaching dramatic levels. In addition to the preferential financial treatment given to nuclear power, including massive limits to liability, utilities demand state guarantees for fixed electricity feed-in at price levels more than twice the market price, plus inflation, and indexed for periods of several decades to be able to build nuclear power plants.

On the other hand, an argument put forward by the nuclear power lobby in favour of new builds is the claim that nuclear power is low cost in operation.

In this context, the question of costs of nuclear power was chosen as the main topic of the Joint Project 2013/2014. This study is one of the main outputs of the work done by the Joint Project group on this subject.

This study aims to contribute to the discussion of this complex issue and focuses on the following topics:

Which costs are included in the price of electricity generation and which costs are not? Four topics will be analysed to what extent they are included in price generation:

- costs of nuclear new-build
- costs of radioactive waste disposal
- costs of decommissioning
- costs of nuclear accidents and liability

An overview for the general reader on these topics is given, but the **specific situation in the Joint Project countries (Bulgaria, Czech Republic, Hungary, Poland, Romania**) is at the focus of this report. The Joint Project NGOs investigated the cost situation for radioactive waste disposal, decommissioning and liability in their countries using online information and writing information requests to competent authorities and summarized the results in texts, which are part of this study. They also evaluated the transparency they were confronted with during their investigation.

For a broader assessment of the costs of nuclear power, see the study "The True Costs of Nuclear Power" commissioned by the Vienna Ombuds Office of Environmental Protection (Wallner/Mraz 2013).

Acknowledgements

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Special thanks goes to Steve Thomas, professor at the University of Greenwich, for providing helpful comments.

3 OVERVIEW OF COSTS

This chapter gives an overview of the cost components of nuclear power and identifies their contribution to the total costs.

This study does not cover all the cost factors but focuses on the key topics and the situation in the Joint Project countries (see Chapter 2).

The following costs are incurred in generating nuclear power:

- fixed costs, e.g. construction and decommissioning of the NPP[1]
- variable costs for operation and fuel

These costs are included in the final price of nuclear power – others like the costs for nuclear accidents or state aid, however, are not. Therefore, this chapter differentiates between "costs included in the price" and "costs not included in the price".

3.1 COSTS INCLUDED IN THE PRICE

The total costs of nuclear power are made up from different components, each differing in the extent to which they are reflected in the total price.

The following provides an overview of those costs and explains their impact on price:

- Investment costs for construction, including interest costs during construction
- O&M – Operation and Maintenance (costs incurring during operation, excluding fuel costs)
    - Fixed costs (independent of the amount of electricity produced):
        - Maintenance costs: significant cost increase likely during times of operation
        - Personnel costs
        - Insurance, taxes
    - Variable costs components (exclusively dependent upon the amount of electricity produced)
        - e.g. costs of fuel purchase, variable maintenance costs
- Fuel costs including waste disposal management and final repository
- Decommissioning costs (dismantling the NPP = investment costs, which are incurred in the future)

[1] It should be kept in mind that costs are not independent of the amount of electricity produced. For example, the amount of power produced leads to different levels of irradiation of the plants that will impact on decommissioning.

Table 1: Cost Components of Nuclear Energy

Type of Costs	Total Share of Costs [%]	
	According to Fig. 1 (Rogner 2012)	According to Fig. 3 (Rogner 2012)
Investment Cost	~ 56-72%	60%
Fuel Costs incl. Costs for Repository	~ 17-26%	20%
Costs for Operation and Maintenance	~ 10-17%	20%
Decommissioning	~ < 1%	1-5%

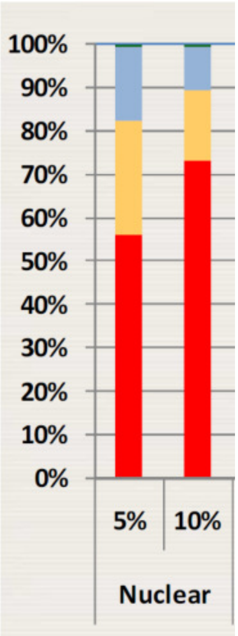
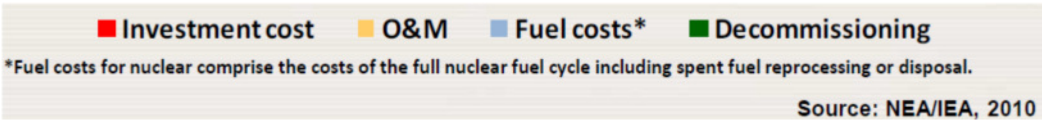


Figure 1: Generating cost structure of nuclear power production including IDC (implied interest during construction = interest rate during construction time, 5% or 10%) (Rogner 2012)

O&M = operation and maintenance



This figure illustrate the individual types of cost and their contribution to the total costs, according to different studies. The data clearly shows that the variable costs of nuclear power plants are relatively low compared to the total costs. As a rule of thumb, it is legitimate to assume that fixed costs make up 2/3rds of electricity production costs (Thomas 2005). Also significant are an NPP´s investment costs, which again are heavily dependent on the interest rate used (as pointed out in Figure 1). Construction costs have been going up much faster than the operating costs and based on expected costs that will inevitably mean the fixed cost percentage rises.

The issue of construction costs is a currently much discussed topic; it has returned to the international agenda because the current power plant fleet is aging. The average age of operating reactors worldwide reached 27 years in May 2012; in comparison, the last 145 reactors which were shut down had an average age of 24 years (keeping in mind that some countries influence this average value with their especially long lifetimes). This explains the nuclear industry's need for new builds. This situation is a consequence of the wave of new builds in the 1970s and 1980s, which then slowed down and was overtaken by the number of shutdowns (see Figure 4). (Schneider et al. 2012)

The **costs of new-build** are covered in **Chapter 4**. Costs of new-build are a key factor for the costs of nuclear power. The costs of **radioactive waste storage** and **decommissioning** are covered in **Chapter 5**.

3.2 COSTS NOT INCLUDED IN THE PRICE

Since the very beginning of commercial use of **nuclear power** this type of energy generation has enjoyed **an exceptional position**: As part of the Manhattan Project, research was undertaken into nuclear fission with the purpose of building nuclear weapons – financed by state funds. After the "Atoms for Peace" speech of U.S. President Eisenhower in 1954, the results of this research were spread worldwide for non-military use. The USA sold a number of demonstration plants cheaply to countries like Italy, Japan, Spain, France etc.. In 1957, this led to the founding of the IAEA (International Atomic Energy Agency) with the goal of accelerating and spreading nuclear power´s contribution to peace, health and prosperity worldwide – simply put, the spreading of commercial (non-military) use of nuclear power was to be promoted. The IAEA currently employs around 2,300 people; in 2012 its budget was more than 400 million euros[2].

The legal status of nuclear energy is also extraordinary: since its founding in 1957, the EURATOM Treaty has held a unique legal position in Europe, dedicated to promote the development of nuclear power in Europe by means other than just research. Since 1957, research and the expansion of nuclear power have been driven using public funds – a special status not granted to any other form of energy generation. This special status has made it possible to shift parts of the cost to the taxpayers.

The following is an overview of the costs that are not included or are inadequately covered:

- **Costs of Full Insurance**
  Due to current liability regimes, nuclear power plants do not have to pay for insurance to fully cover any damage caused by a Beyond Design Basis Accident (BDBA). In case of an accident, the costs will have to be borne by those potentially damaged, and by the state – i.e. the taxpayer again. International conventions (Paris, Brussels, Vienna, Price Anderson for USA) were founded to (partially) cover these costs, but not all countries are members and have ratified these conventions. It was a very early acknowledgement that if there was liability on utilities, nuclear was not feasible.
- **External Costs of the Fuel Cycle**
  External costs are costs that are not born by the polluter – usually society has to pay for those costs. When assessing processes and products, their environmental impact over the complete life cycle must be taken into account. Therefore, in the case of nuclear power it is necessary to assess aspects such as impact on the environment and health, not just during the operation of the nuclear power plant but along the entire nuclear fuel chain; this starts with uranium mining, enriching the fuel, and all the way to decommissioning the plant and final disposal of the fuel. Negative impacts on the environment and health caused by the nuclear fuel chain are not reflected in the electricity production costs and therefore count as external costs.
- **Coverage of insufficient resources for decommissioning and final disposal**
- **Nuclear power research (EURATOM)**
- **Institutional framework of nuclear power (IAEA, state safety authorities, …)**
- **State aid for new build (loan guarantees, tax relief)**

[2] http://www.iaea.org/About/budget.html, accessed on 20 June 2013

Hiesl (2012) has stated that a full insurance to cover a Beyond Design Basis Accident would have high potential impact on the electricity costs. Possible **costs** of a **BDBA** and the **influence of nuclear full liability on the costs** of nuclear power as key factor for the costs of nuclear power are covered in **Chapter 6**.

4 COSTS OF NUCLEAR NEW-BUILD

4.1 GENERAL INFORMATION: HOW MUCH DOES IT COST TO BUILD A NUCLEAR POWER PLANT?

4.1.1 DEFINITIONS

Construction costs for a NPP are usually quoted as so-called **overnight costs**. These are the costs which would incur if the nuclear power plant could be build "overnight" – i.e., all costs occurring at once, at today´s prices. The overnight costs usually include the cost of the first fuel charge, however, they exclude the interest charges incurred during the construction period (interest during construction IDC) and general inflation. Overnight costs are usually given as costs per kW of installed capacity (Böll 2010). There is no standardized calculation of overnight costs – sometimes the overnight costs only include the EPC costs (engineering, procurement, construction), and in other cases they also include costs of land purchase, project management and license costs (Radovic 2009).

Investment costs include overnight costs and the IDC (IDC = Implied interest during construction) (IEA/NEA/OECD 2010). If the rates incurred during construction time (costs of capital) and price rises are also included, the construction costs increase significantly – an increase of the assumed interest rate of e.g. 5% to 10% results in a significant change of costs (see Figure 1 and Figure 2):

The **interest rates** incurred for this purpose and other costs constitute the **costs of capital** (equity costs and debt costs). The costs of capital differ significantly depending on the company´s credit rating, project risk and the county-specific risk. When the risk of default of payment is assessed as being low, e.g. due to state guarantees, the credit costs decrease (Böll 2010, p. 81-82). The risk rating for nuclear power plants is of particular importance, because high-risk interest quickly makes construction economically uninteresting for investors.

Large scale projects, such as the construction of nuclear power plants, are usually financed using debt capital (loans) and equity capital (contributions by the plant owners).

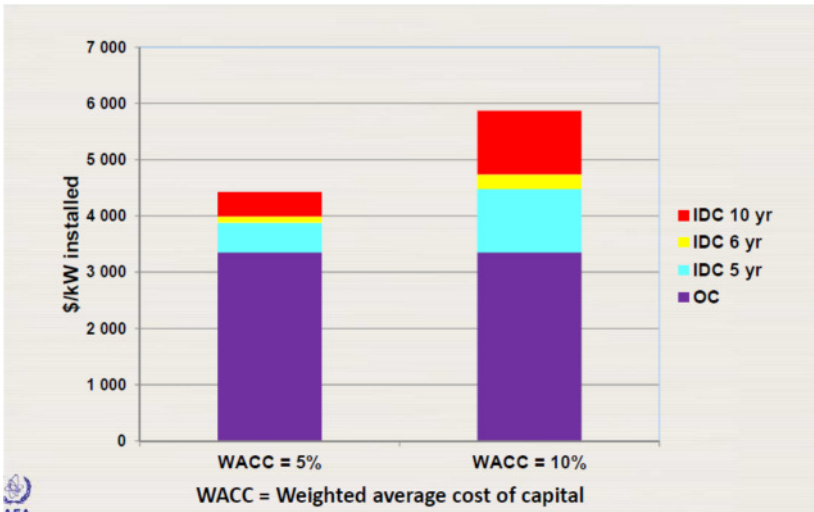


Figure 2: Construction cost dependence on interest rate and length of construction period – OC = Overnight Costs, IDC = Interest during Construction (Rogner 2012)

4.1.2 SHARE OF THE OVERALL COSTS

Investment costs are of key importance to the overall costs of the NPP: depending on the selected assumptions and methods of calculation, they account for half or even two thirds of the overall costs (see Figure 1, Figure 2 and Figure 3). The data provided by different studies, however, differs significantly.

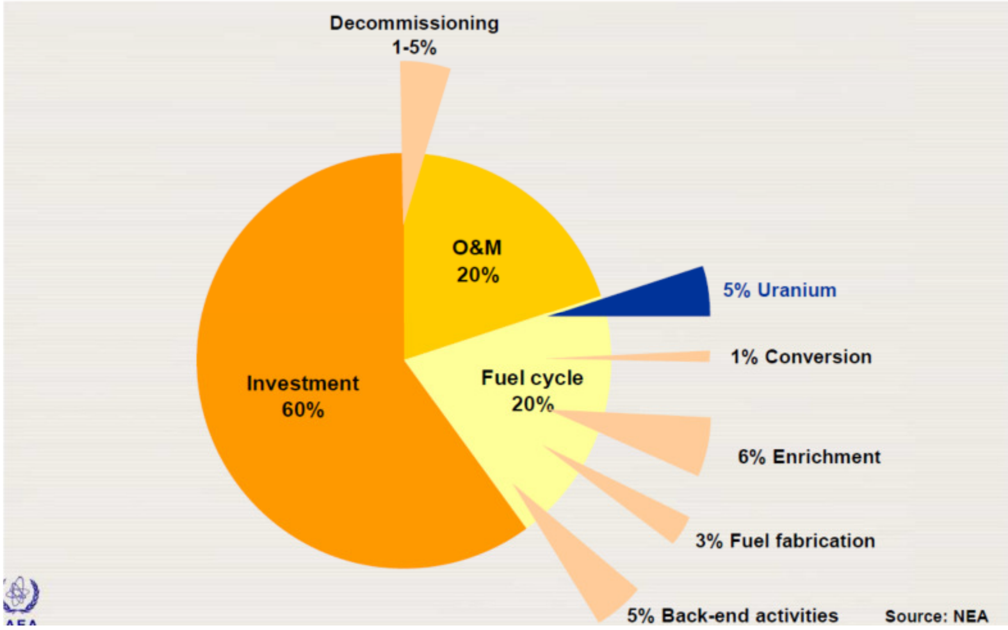


Figure 3: Distribution of overall costs of nuclear energy generation (Rogner 2012)

According to the rule of thumb, ***approximately two thirds*** of the overall costs are made up of ***fixed costs***. The ***largest portion*** is devoted to the ***construction*** of the nuclear power plant – or the related payment for loan instalments and interest rates. Only a small part is set aside – at least mathematically – for the decommissioning of the nuclear power plants. The operational and fuel costs of nuclear power plants are relatively small in comparison to the fixed costs. (Thomas 2010)

This leads to creation of a ***paradox situation***: once the nuclear power plant has been completed, in most cases[3] it makes more sense to continue operating the NPP, in order to amortize the construction costs, even if cheaper, alternative forms of energy generation are available (Thomas 2010).

4.1.3 NEW BUILD

Figure 4 explains why the subject of nuclear new builds is currently of such interest. Since the start of commercial use of nuclear energy, there have been two main construction waves: in the mid-70s and mid-80s. Until 2002, more reactors went online almost every year than were shut down. After 2002 this trend reversed: the ***reactors*** built

[3] The closure of five plants in the US was announced in 2013 because the cost of keeping them in operation was more than cost of replacing them. In some cases, it was high repair costs but others it was high operating costs and low gas costs. (Thomas 2014)

during these main construction waves successively reached the ***end of lifetime***. Their host countries now have the following options to maintain installed capacity: construction of new reactors, extending the lifetime of existing nuclear power plants, and steering energy policy towards an alternative, nuclear power-free direction.

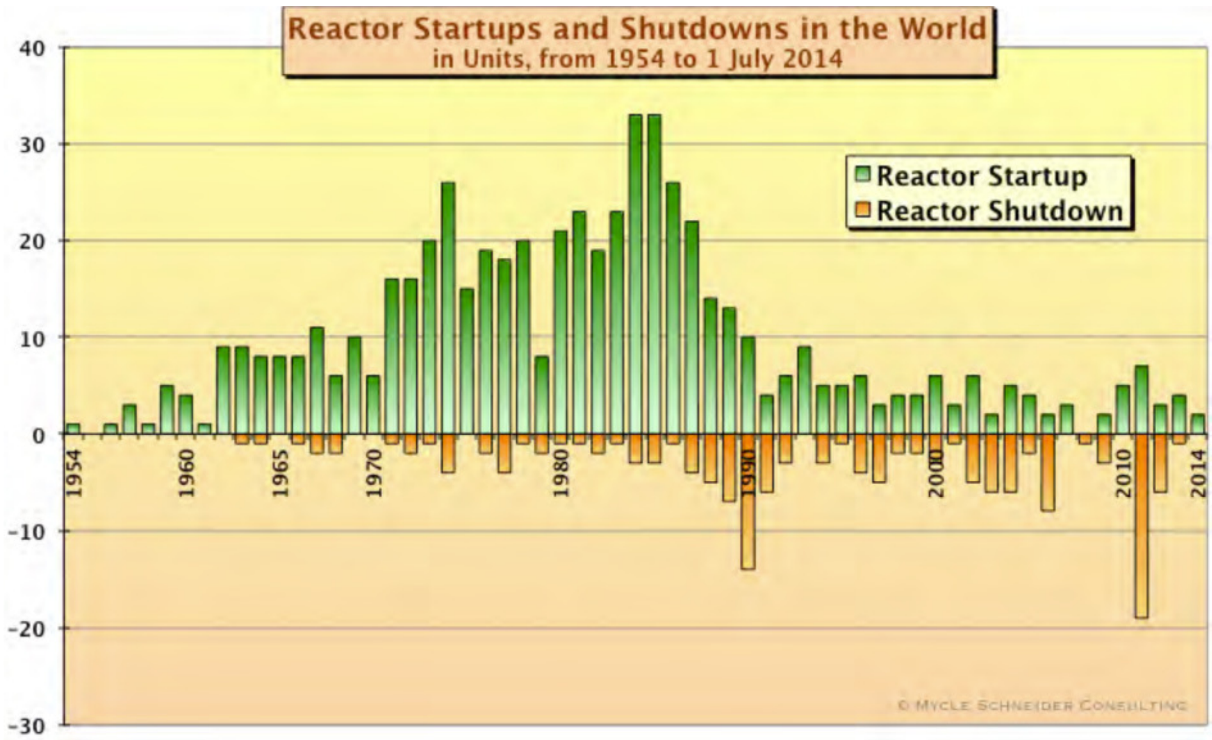


Figure 4: Reactor Startups and Shutdowns - Source: (Schneider et al. 2014 based on IAEA-PRIS data)

The nuclear power lobby hopes to turn this potential new build boom into a chance to obtain new orders. However, new builds have become much more expensive and difficult than in the 1970s. The following chapter examines the development of costs for new build. After this we show how states and the nuclear lobby are attempting to overcome the obstacle of high and risky investment costs and enable new builds.

4.2 LEVEL AND DEVELOPMENT OF COSTS FOR NEW BUILDS

4.2.1 LEVEL OF COSTS OF NEW BUILD

The different data on costs of nuclear power plants are ***hardly comparable***, because cost estimates usually rely on different definitions of costs, assumptions and goals. For example, the overnight costs compared to the investment costs do not take into account cost overruns due to inflation and interest during construction (IDC). Moreover, the different costs definitions are not standardized. In addition, the assumed ***interest rate*** has a significant impact on the calculated costs (See Figure 1). The interest rate level will vary according, amongst others, to perceived investment risk falling on the financiers – long-term guaranteed purchase contracts can keep the perceived risk and thereby the interest rate low.

For outsiders, these ***non-transparent estimates*** make it almost impossible to compare the different costs. Operators can manipulate those figures to fit their purposes.

A very good illustration of this was calculated for the MIT[4] study in 2009: the study compared the costs of two bids made for a U.S. reactor – which originally differed by a factor of 3. However, once the cost estimates were broken down to fit the same method of calculation, it turned out that the costs of the reactors on offer were almost the same ($ 3,480/kW vs. $ 3,530 kW) (Du/Parsons 2009).

In spite of the enormous difference in the cost estimates, one fact is obvious – nuclear power plants are expensive. Some figures on this:

- Du/Parsons (2009) gives the overnight costs in 2007 for several offers for U.S. reactors at between ***2,930 and 7,745 US$/kW***. The overnight costs of NPP actually built in Japan and Korea between 2004- 2006 are given at 2,759 to 3,357 $/kW.
- The overnight costs for 2007 are given at 4,000 US$/kW in the MIT basic scenario (Du/Parsons 2009, p. 41) – for ***2013*** overnight costs were calculated at ***4,776 US$/kWh.*** For a 1,000 MW NPP, this amounts to overnight costs of ***4.8 billion US$ (ca. € 3.6 billion)***[5]***.***
- OECD provides the following figures for new build costs – the enormous difference between overnight costs and investment costs becomes clear:

Country	Technology	Net capacity	Overnight costs[1]	Investment costs[2]	
				5%	10%
		MWe	USD/kWe	USD/kWe	
Belgium	EPR-1600	1 600	5 383	6 185	7 117
Czech Rep.	PWR	1 150	5 858	6 392	6 971
France*	EPR	1 630	3 860	4 483	5 219
Germany	PWR	1 600	4 102	4 599	5 022
Hungary	PWR	1 120	5 198	5 632	6 113
Japan	ABWR	1 330	3 009	3 430	3 940
Korea	OPR-1000	954	1 876	2 098	2 340
	APR-1400	1 343	1 556	1 751	1 964
Netherlands	PWR	1 650	5 105	5 709	6 383
Slovak Rep.	VVER 440/ V213	954	4 261	4 874	5 580
Switzerland	PWR	1 600	5 863	6 988	8 334
	PWR	1 530	3 681	4 327	5 098
United States	Advanced Gen III+	1 350	3 382	3 814	4 296
NON-OECD MEMBERS					
Brazil	PWR	1 405	3 798	4 703	5 813
China	CPR-1000	1 000	1 763	1 946	2 145
	CPR-1000	1 000	1 748	1 931	2 128
	AP-1000	1 250	2 302	2 542	2 802
Russia	VVER-1150	1 070	2 933	3 238	3 574
INDUSTRY CONTRIBUTION					
EPRI	APWR. ABWR	1 400	2 970	3 319	3 714
Eurelectric	EPR-1600	1 600	4 724	5 575	6 592

Figure 5: Overview of costs of new build (IEA/NEA/OECD 2010, p. 59)[6]

[4] Massachusetts Institute of Technology

[5] Notes from the .xls of the study by Du/Parsons (2009) = basis for MIT (2009): "Example assumes a total EPC overnight cost of $3,333, an inflation rate of 3%, a 20% factor for owner's cost and an allowed capital recovery charge of 11.5%."

[6] Overnight costs include pre-construction (owner's), construction (engineering, procurement and construction) and contingency costs, but not interest during construction (IDC).

4.2.2 CONSTRUCTION TIME

Radovic (2009) examined the construction times of all commercially operated reactors and arrived at the conclusion that the average construction time is ***6.9 years*** (with a standard deviation of 3.34 years). However, current projects in particular are significantly exceeding this average construction time.

This average construction time is subject to significant fluctuations: Figure 6 shows the continuous increase in construction times since the 1950s. While the first decades of commercial nuclear power use were characterized by very homogeneous construction times, the variations between different countries have continued to grow since the 1990s. While Japan, South Korea and China have enjoyed construction times of 4.4, 4.5 and 5.9 years respectively in the past two decades, construction times in other parts of the world are escalating, reaching to ***over 10 years*** (Schneider et al. 2014). Also construction times in China are behind schedule: The two Sanmen plants are both at least two years behind schedule and 20% over budget. Also the two Haiyang plants have a delay of two years, and nearly all other plants under construction are delayed by at least a few months. (NIW 2014)

Partly due to interest payments but also the costs associated with dealing with the problems that led to them, construction time overruns inevitably lead to overruns of scheduled costs.

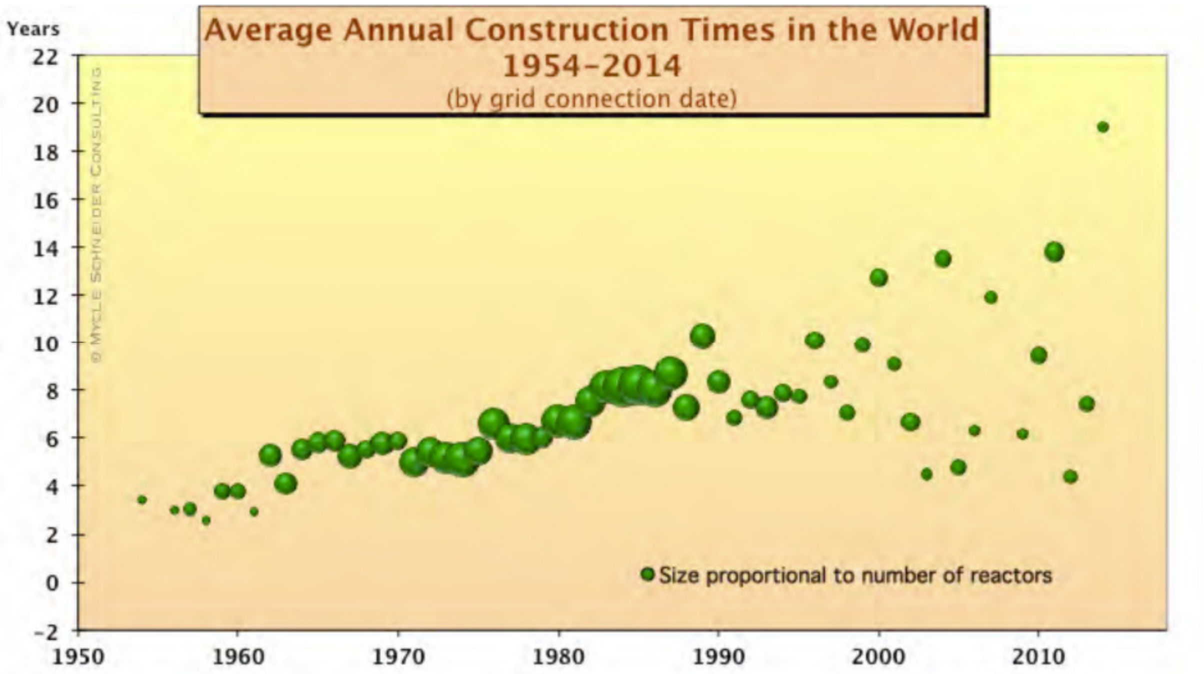


Figure 6: Development of average construction times 1954-2012 (Schneider et al. 2014)

Investment costs include overnight costs as well as the implied interest during construction (IDC).

4.2.3 DEVELOPMENT OF COSTS OF NEW BUILD

Only very few nuclear construction projects are completed during the scheduled cost and time limits – many overrun their planned budgets and construction time many-fold (Greenpeace 2013). In the past decade the construction costs for NPP increased many-fold, sometimes even by a factor five (Böll 2010).

The ***Massachusetts Institute of Technology*** calculated the ***increase of construction costs of 15% per year (MIT 2009 as Update of MIT 2003)***. The overnight costs in the basic scenarios increased in this comparison from ***2,000 to 4,000 US$/kW*** (MIT 2009).

In the past the nuclear industry again and again announced better prices due to ***the learning effects***, however, ***they did not take place*** in reality. Reasons for this are e.g. a continuous increase in safety regulation and strong decrease in the number of nuclear power plants ordered (Biermayr/Haas 2008) Therefore, it is most likely not the case that mass production would have economic advantages (Böll 2010, p. 77/7). Rather the contrary – nuclear power is producing a negative learning curve: In the past decade the cost estimates for the new-build of NPP increased five-fold (Thomas 2010, p. 8).

4.2.4 OLKILUOTO

Around year 2000, when the promotion of this new reactor generation was started for the first time, the costs were ***originally estimated*** to be US$ 1,000/MW, i.e. ***one billion US dollars*** for a 1,000 MW NPP.

An example for the ***extreme overrun in costs and construction time*** is Areva´s EPR reactor construction project in Olkiluoto, Finland. The EPR (European Pressurized Reactor) was one of the first construction projects of Generation III+. Since the project start in 2004 problems kept occurring, e.g. strength of the concrete, welding seam quality, supplier´s lack of expertise and a low quality control over contractors. The problem seems to be never ending – the expected ***completion date*** was already delayed from ***2009 to 2016[7].*** Construction costs have more than doubled since the original estimate from 3.2 billion euro to 8.5 billion euro (Status: Dec. 2012[8]).

Despite all the problems at Olkiluoto, this latest price estimate is still less than the price agreed between EDF and the British government for Hinkley Point with GBP 16 billion for 2 EPR à 1,600 MW (GBP 8 bn. each), resulting in GBP 5.1 billion = US$ 8.7 bn. per 1,000 MW (Schneider et al. 2014).

The Finnish NPP Olkiluoto is being built under a so called turnkey contract of 2003. Turnkey means that Areva has committed to carry out all work necessary (including not yet foreseeable work) for a fixed price regardless of what the costs actually are. Signing such a contract investors considered as being too risky in most cases, because they are well aware of the possibly enormous cost overruns. (Schneider et al. 2011) TVO and Areva are blaming each other as being responsible for the delays and are already fighting in an arbitration court since 2008: Areva demanded

[7] http://www.world-nuclear-news.org/NN-TVO_prepares_for_further_Olkiluoto_3_delay-1102134.html, accessed on 1 July 2013

[8] http://www.reuters.com/article/2012/12/03/us-edf-nuclear-flamanville-idUSBRE8B214620121203, accessed on 1 July 2013

1.9 billion euro from TVO in May 2011, TVO then demanded Areva[9]to pay 1.8 billion euro damage compensation in October 2012.

The French EPR counterpart of Olkiluoto is under construction in Flamanville. The situation there does not seem to be any better – construction started in 2007, should have been completed in 2012, but is delayed until at least 2016 with. The cost was estimated in 2007 to be €3.2 bn. but by 2013, the estimated cost was, like Olkiluoto, €8.5 bn.

4.3 BENEFITS FOR NPP NEW-BUILD

As explained in Chapter 4.2., a necessary condition for the construction of a nuclear power plant is the availability of an enormous amount of money. The argument that nuclear power is more economic than renewable energies is hard to sustain. (Schneider et al. 2011)

A significant contribution to the high cost of nuclear is the fact, that financing institutions are increasingly being asked to bear the high investment risk associated with building a nuclear power plant – causing interest rates and overall costs to rise. In all of Europe, current new-build effort is burdened with cost problems. By providing various benefits for NPP new-build, the nuclear lobby attempts to shift this funding problem on to other stakeholders. The following chapter is providing an overview over such benefits.

4.3.1 STRIKE PRICE: THE BRITISH EXAMPLE

Current developments under way in U.K. could also have significant impacts on new-build projects in Europe; the so-called „Contract for Difference" (CfD) Behind this term from financial economics is a mechanism to give a guaranteed electricity feed-in-price (Strike Price) under a long-term contract for nuclear investors with the goal to make new-build of NPP profitable and reduce the risk for financiers.

Firstly a brief historic outline to explain the background, which led to this development:

2006, the British government announced the intent to start a **nuclear new-built program** with a view to replacing the heavily aging nuclear power plant fleet. This program was to be market driven – **state aid was firmly excluded**.

In **2007,** the government initiated the **"Generic Design Assessment"** (GDA) which should conduct comprehensive analysis of certain reactor design to asses non-site specific characteristics for potential reactors for new-build already beforehand. Assessed were Areva´s EPR, the AP1000 by Toshiba/Westinghouse, the ESBWR by Hitachi-GE and the ACR1000 by AECL. The reactor construction was expected to take place at already existing NPP sites.

In **2010,** the British government announced that an electricity market reform would be necessary to guarantee security of energy supply also in future. The possibility of **subsidizing** nuclear energy **was not completely excluded** any more at this point.

[9] http://www.handelsblatt.com/unternehmen/industrie/finnischer-versorger-tvo-fordert-1-8-milliarden-euro-von-areva/7204410.html, accessed on 1 July 2013

In **2011,** the government published a White Paper on the Electricity Market Reform – among other issues it defined a) to determine a **CO_2 minimum price** (Carbon Floor Price) and b) long-term contracts (**feed-in-tariffs with contracts of difference**) to attract investors for low-carbon technologies. The White Paper assumes that the CO_2 minimum price will have increased to € 36 per ton by 2020 (in 2010 prices); on the one hand this is exactly the threshold which had been calculated by the British government in 2008 for the economic viability of nuclear energy – on the other hand 2020 had been the year the first new British NPP was to go online. The condition obviously had been tailor-made for the promotion of nuclear energy.

At the end of **2011, only one** of the four potential **suppliers was left** over (Areva's EPR reactor). The reactor ACR1000 and ESBWR had been withdrawn. Westinghouse-Toshiba´s reactor AP 1000 however received the Interim Design Acceptance Confirmation (IDAC) from the ONR (Office for Nuclear Regulation) at the end of 2011, but was not prepared to continue working on the project to resolve the remaining issues if it would be chosen as the preferred bidder. In such a situation it is not possible to have market driven process.

In 2013, the Environmental Impact Assessment for the first British new-build project was completed, the construction of two EPR reactors by EDF at the Hinkley Point site. The British state secretary for energy and climate **decided in favor of the application** on the NPP Hinkley Point C

At the end of **June 2013**, the British government announced its intention to make available **a state loan guarantee** of up to **GBP 10 billion** for the project Hinkley Point.[10] This loan guarantee enables significantly lower construction interest rates for this project and much decreases the construction costs. This allowed the British government to keep the Strike Price at a politically acceptable level

In **October 2013**, the British government announced it had reached agreement with leader of the consortium applying to build Hinkley Point C, the French company, EDF.[11] This decision was taken after **intensive negotiations between EDF and the British government** concerning the level of the **Strike Price.** The mechanism **Contract for Difference** (CfD) uses state funds (provided by electricity consumers) to guarantee the income of nuclear energy suppliers, when the electricity price drops under a certain in advance decided price (Strike Price). In case the electricity market price drops under the agreed Strike Price, the state pays the difference to the electricity generating utility. If however the market price rises above the Strike Price, the electricity generator has to give the excess sum to the state. EDF insisted on the Strike to secure the high investment of project of ca. 16 billion pound. With the CfD in place, the state would guarantee a fixed electricity price to the electricity producer.

The strike price is set at GBP 92.50 per MWh (expressed in real terms, as of 2012), if EDF undertakes to build a second nuclear power plant at Sizewell C using the same design, the strike price would become **GBP 89.50 per MWh**. The strike price will be fully indexed to the Consumer Price Index - based on current assumptions, this would translate into a nominal strike price of GBP 279 per MWh in 2058, the last year of application of the CfD scheme. According to the EC, the overall amount of aid can vary between GBP 4.78 and 11.17 billion depending on the assumptions taken. (EC, 2013)

This decision confirms the British government´s strong focus on nuclear power. Other countries are awaiting the developments in England and in case of a success they are ready to introduce the same system in their countries. For example, in April 2013 the Czech Minister of Industry announced that the completion of the two new units at

[10] http://www.bloomberg.com/news/2013-06-27/u-k-s-nuclear-plan-advances-with-15-billion-treasury-backing.html, accessed on 2 July 2013

[11] https://www.gov.uk/government/news/initial-agreement-reached-on-new-nuclear-power-station-at-hinkley accessed on July 29, 2014

the Temelin site in 2025 would most likely be delayed, because the additional capacity would not be needed until 2030. Later, CEZ cancelled the tenders for the two new units and the project was completely put on ice: the current electricity price was regarded as too low to result in viable construction costs for CEZ, also the lack of government guarantees was cited. (Schneider et al. 2014, p. 134)

Previously, the European Commission had been quite positive towards plans of countries like U.K., Bulgaria, Czech Republic and Finland to give state aid for nuclear energy generation: In March 2013, the European Commission published the consultation paper on the „Environmental and Energy Aid Guidelines 2014-2020", which among other ideas suggested to allow state aid for nuclear power as a low-carbon technology.[12] During the consultation phase this paper met enormous resistance, because potential CO_2 savings are pitted against the most serious problems of nuclear energy, e.g. the unsolved question of a final repository for high level nuclear waste and the residual risk of severe accidents, which still cannot be excluded. As a general rule, state aid for nuclear power should not be possible, because the Treaty on the Functioning of the European Union states in article 107 (1) states that any aid granted by a Member State or through State resource in any form whatsoever which distorts or threatens to distort competition by favoring certain undertakings or the production of certain goods shall, in so far as it affects trade between Member states, be incompatible with the internal market.

But in December 2013, the EC delivered a very sceptic initial take on the take on the UK Government's deal with EDF, concluding the measures definitely constitute state aid. In its initial analysis (EC 2013) the EC suggested that the deal may not be proportionate and risked substantially over-compensating EDF. After that, the EC launched a full investigation on the measures supporting Hinkley Point.[13] By august 2014, the process was still ongoing.

4.3.2 STATE GUARANTEED LOANS

An option to decrease the debt capital costs of NPP construction is the use of state loan guarantees. In case of payment default of the construction company, the state takes over the loan default. With this loan security the loan provider takes on a very low loan default risk only and therefore very low loan interest rates can be agreed. Loan rates being a very significant share of the construction costs, such a state loan guarantees is a key advantage for the construction company. Ultimately this means, that the ***financial risk is shifted to the tax payers*** (Schneider et al. 2011).

The loans for the Finnish NPP ***Olkiluoto***, currently under construction, were partly covered by such state credit guarantees provided by the French and Swedish government, leading to very low credit interest rates (2.6%). This loan guarantee was called unfair state aid – the European Commission however did not support this claim, because the borrower had paid a fee for the loan guarantee. The actual amount of this fee was not made public – therefore it is not possible to determine, whether this fee was so high as to reflect the state´s taking over the credit risk. The lack of transparency concerning the sum of this fee however raises doubts (Schneider et al. 2011).

[12] Paragraph 48 of this consultation paper states that some member states consider aid for nuclear power to support energy supply security and possible CO_2 savings. Paragraph 51 adds that this wish of some member states to extend state aid also to other types of low carbon energy generation, justifies a in depth discussion.

[13] source: http://www.greenpeace.org.uk/newsdesk/energy/news/briefing-european-commission-decision-uk-state-aid-hinkley-point-c-nuclear-plant

4.3.3 TAX RELIEFS

Another option to grant state aid to nuclear power are tax reliefs. In 2003 for example in the U.S. the suggestion was made to give a tax relief to nuclear power of ***18 US$/MWh*** (0.018 US$/kWh) to make the electricity generated by new NPP competitive with electricity generated from other energy sources (Böll 2010, S. 95).

The effort undertaken until now to initiate nuclear new build in the U.S. carried very little fruit until now: In 2015 over 40% of reactors will have been in operation over 40 years and therefore exceeded their originally planned life time (Schneider et al. 2012). In 2013, only four reactors were under construction, plus Watts Bar, which started construction in 1972.[14] The Bush 'Nuclear 2010' programme launched in 2002 to get new reactors built with an expectation the first plant would be in service by 2010 only saw first construction on the first four units by 2013. It is far from clear whether the programme will lead to any more plants being built. The Bush programme included provision for loan guarantees up to 80% of the expected cost. (Thomas 2014) As a cheaper alternative to new build a majority of reactors will undergo life time extension to reach 60 years of operation. The NRC is currently considering plant life extension applications for 19 nuclear reactors. These decisions depend on the completion of a new "waste confidence rule" relating to long term management of nuclear waste. (Schneider et al. 2014)

4.4 STATUS OF NUCLEAR NEW BUILD IN THE JOINT PROJECT COUNTRIES

4.4.1 BULGARIA

Reactors in planning stage

In Bulgaria, there are two reactors in operation at Kozloduy NPP of the Soviet VVER-1000 design. Four earlier reactors of the VVER-440 design were closed in 2002 for the first two units and 2006 for the second two.

A new-build project existing since the 1980 is NPP ***Belene***. In 1986, the construction of the first of four planned reactors at the Belene site started – the chosen reactor type being the same as the two plants at KozloduyVVER-1000. Due to massive protests of the population, the construction work was cancelled in 1990. In 2002, the Bulgarian Parliament abolished the decision on the construction stop - in 2004, an Environmental Impact Assessment was carried out. In 2008, the Belene project was already severely delayed. Concerns increased after a heavy earthquake on April 25th 2009, which affected Belene. After that, problems with financing increased - the projected costs were stated and contracted at € 4 billion at the beginning - the actual estimation at the end of the project exceeded 10 billion euros. In 2013, the Belene project was cancelled in favour of a new reactor at NPP Kozloduy

In 2009, the Bulgarian Ministry of Economy announced the planned construction of a 1000 MW reactor in Kozloduy (**Kozloduy 7**), a Feasibility Study was being carried out at that time. In 2010, the feasibility of the project was confirmed. In 2012, the Council of Ministers approved the construction of Kozloduy 7. In 2012, a transboundary Environmental Impact Assessment started. Construction start is envisaged for 2016.

[14] http://www.iaea.org/pris/CountryStatistics/CountryDetails.aspx?current=US, accessed on Aug 2014

4.4.2 CZECH REPUBLIC

In the Czech Republic there are currently six reactors at two locations, two relatively new units of 1000MW at Temelin and four units of 440MW at Dukovany, in operation, which provide about a third of the countries' energy demand. The originally planned lifetime was 30 years which the older Dukovany units would reach in 2015-17. At the beginning of 2009, CEZ began the "Long Term Operation" (LTO) Project, with the aim to provide the provisions for a lifetime extension of 10 years. A further extension to 60 years is envisaged.

Reactors in planning stage

In 2008, CEZ announced that two new reactors at Temelin NPP (***Temelin 3/4***) with a capacity of 3400 MW were going to be built – the first reactor is planned to go into operation in 2020. In mid-2008, the relating Environmental Impact Assessment began. In spring 2010, the Environmental Report was published, in 2013, the EIA was completed. The early front-runner was the French Areva EPR design, but was disqualified in 2012, leaving the Russian AES-2006 design as the front-runner.

A Feasibility Study about a ***new reactor at NPP Dukovany*** is being carried out. Furthermore, the Czech Energy Concept of 2013 plans the search for additional locations for NPP after 2040.

In 2013, CEZ announced that ***all decisions*** would be ***suspended for 1 to 2 years*** - including the construction start of Temelin 3 and 4. Economic reasons were behind this decision: The Czech Republic wanted to introduce a system with fixed electricity prices for the nuclear power vendor – but no agreement on this topic was reached.

In March 2014, Prime Minister Bohuslav Sobotka said he would be prepared to back the construction of a fifth reactor at the Dukovany nuclear power plant. Meanwhile, the expansion of the Temelín nuclear power plant in south Bohemia looks increasingly uncertain.[15]

4.4.3 HUNGARY

Reactors in operation

In Hungary, four reactors of the Russian reactor type WWER 440/V213 with a capacity of 440 MW each completed in 1982-87 are operating at Paks NPP.

The lifetime extension of the first reactor for 20 years has already been approved in Dec. 2012. For the other reactors, a lifetime extension programme is currently in progress.[16]

Reactors in planning stage

In the 1980s and the 1990s, the construction of the reactors Paks-5 and Paks-6 was discussed, each time the plans weren't carried out in the end.

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[15] http://www.radio.cz/en/section/news/pm-ready-to-back-a-fifth-reactor-at-dukovany-nuclear-power-plant, accessed on 3 July 2014

[16] http://www.joint-project.org/plex_in_hungary.htm, accessed on 22 Dec. 2013

In 2009, the Hungarian Parliament gave its preliminary approval for the construction, it was announced that foreign investors were necessary for the project. In 2013, five different PWR-reactor types were on the short list: Areva's EPR; the Areva-Mitsubishi Atmea1; Atomstroyexport's VVER-1000 or -1200; the Westinghouse AP1000[3]and Korea's APR-1400.[17]

An Environmental Impact Assessment started in 2013, the documents can be accessed via (http://www.umweltbundesamt.at/umweltsituation/uvpsup/espooverfahren/espoo_ungarn/uvpkkwpaksii/).

In January 2014, rather than proceeding with the open tender, the government signed an agreement with Rosatom to build the two new reactors at the Paks site, with Russia providing 80% of the finance. The draft plan for building the units of up to 1200 MWe each at a likely cost of around EUR 10-12 billion envisages the first unit to be operational about 2023 under Hungarian state ownership. Fuel will be supplied by Russia.[18]

There are many uncertainties about the Russian financing. Beyond geopolitical concerns, many issues are unresolved, and the financing contract favours the Russian interests: while there are no publicly available estimations on the overall costs, it is unknown what can be covered by the loan and there is no timeframe set up for the construction, the conditions for repaying the loan are hard, and there is no arbitration mechanism established.

4.4.4 POLAND

Reactors in operation

Currently, there are no NPPs operating in Poland. In 1990 – after the accident in Chernobyl – the 1972 started construction of the NPP Zarnowiec was stopped, not only due to substantial protests because of the 'Chernobyl threat', but also because of a general phase-out of heavy industry due to change in economic policy trends in Poland and CEE-countries.

Poland as Europe's second biggest producer of coal obtains over 90% of its electricity from coal.

Reactors in planning stage

To reduce its dependency of coal, Poland drastically changed its energy policy and now plans to construct nuclear power plants. In 2008, a road map was published which envisaged the production of nuclear power starting in 2021. In 2009, PGE (Polska Grupa Energetyczna) announced its plans for the construction of two NPPs, with two reactors each, with a total output of ca. 6 GWe. The Polish Parliament voted 2011 in favour of building new NPPs. But the plans were soon delayed, currently a start of nuclear production no earlier than 2024 can be assumed.

After a transboundary strategic environmental assessment process Poland's nuclear power programme (PPEJ) was confirmed by the government on 28th January, 2014.

[17] http://www.world-nuclear.org/info/Country-Profiles/Countries-G-N/Hungary/, accessed on 22 Dec. 2013

[18] http://www.world-nuclear.org/info/Country-Profiles/Countries-G-N/Hungary/, accessed on 3 July 2014

In January 2013 the PGE EJ1selected Australian consulting firm Worley Parsons to conduct a five-year, US$ 81.5 million (ca. PLN 250 million) study, on the siting and development of a NPP. Zarnowiec is among the sites chosen for investigation. (Schneider et al. 2014) The site selection is progressing, a decision is expected in 2016. The construction start in planned in 2019. The EIA for a concrete project of the first NPP is planned to be announced between January 2017 and December 2018 under the procedure of granting of the building permit.

It is, however, unclear, whether Poland will be able to raise the necessary funds for its NPP project – in April 2013, the Polish Prime Minister Donald Tusk announced that the Polish nuclear power programme could not be implemented without state aid.[19]

4.4.5 ROMANIA

Reactors in operation

In Romania, currently two reactors are in operation at the Cernavoda NPP.

In the 1970s, originally five reactors were planned. The construction of Cernavoda-1 began in 1980, the construction of the other reactors in 1982. In 1991, the work on the reactors 2-5 was stopped.[20] Only in the year 2000, the construction of Cernavoda-2 was continued, in 2007, the reactor was commissioned.[21] Cernavoda 3-5 have not been finished to date.

The operation time of both reactors is planned to be 60 years each.

Reactors in planning stage

The reactors 3 and 4 of Cernavoda NPP are now to be completed. Significant parts of the buildings already exist.

In 2007, an Environmental Impact Assessment was made on this topic. The documentation including an Austrian expert statement can be found under:

http://www.umweltbundesamt.at/umweltsituation/uvpsup/espooverfahren/rumaenien/uvpcernavoda/

The construction start is unclear due to problems with financing.

In 2012, a feasibility study on the completion of Cernavoda-5 came to the conclusion that the project was not feasible out of economic and technical reasons. In 2013, the Romanian national nuclear company Nuclearelectrica

[19] http://www.climatesceptics.org/europe/poland/poland-s-nuclear-plant-project-needs-state-backing-pm, accessed on 20 Dec. 2013

[20] http://www.world-nuclear.org/info/default.aspx?id=364&terms=%22nuclear%20power%20in%20romania%22, accessed on 20 Dec. 2010

[21] http://www.global2000.at/site/de/wissen/atom/atomeuropa/article-akwrumaenien.htm, accessed on 20 Dec. 2010

has signed a letter of intent for the development of the Cernavoda nuclear power plant units 3&4 by China General Nuclear.[22]

Furthermore, the construction of a NPP on another site than Cernavoda was discussed – the site was envisaged to be in Transylvania. Since June 2010, there were no news on the project.[23]

[22] http://powermarket.seenews.com/news/romania-plans-to-halt-works-on-cernavoda-n-plant-unit-5-341708, accessed on 20 Dec. 2010

[23] Information of Terra Mileniul III - Lavinia Andrei, Aug 2014

5 COSTS OF RADIOACTIVE WASTE STORAGE AND DECOMMISSIONING

5.1 GENERAL INFORMATION ON RADIOACTIVE WASTE STORAGE

Radioactive waste is typically divided into three categories (high-, intermediate- and low-level, HLW, ILW and LLW, respectively). Waste is stored before packaging and final disposal in a final repository. Whilst there is considerable experience of LLW disposal, there is no operating disposal facility for ILW and for HLW, the first site has yet to be identified.

Final repositories for HLW present a particularly serious challenge. This is technically difficult, because safe storage, ensuring the material remains isolated from the environment, needs to be guaranteed for thousands of years[24]. It is almost impossible to make cost estimates of the cost of final repository of High Level Waste because worldwide no such final repository for HLW is in operation. This leads to a wide range of cost estimates for the final repository:

- According to WNA (2013b), costs of the back-end of the nuclear fuel chain are up to 10 % of the total cost per kWh
- The Swiss Nuclear Safety Authority ENSI provides absolute costs of fuel disposal according to Table 8 (ENSI 2012) for the whole nuclear disposal process (incl. costs already incurred during operation of the NPP and the post-operation phase)
    - from CHF 2,153 million for NPP Muehleberg (373 MW net) = **€ 1,763,000,000**
    - to CHF 5,400 million for NPP Leibstadt (1190 MW net) = **€ 4,422,000,000**

Table 2: Estimate of Overall Costs in Swiss Francs by KS11, based on the Price Level of 2011 – Data in Million Swiss Francs (ENSI 2012, p. 26); KKB = NPP Beznau, KKM = NPP Muehleberg, KKG = NPP Goesgen, KKL = NPP Leibstadt, ZZL = Central Interim Storage Wuerenlingen

KS11 PB11 [MCHF]	KKB	KKM	KKG	KKL	ZZL	KKW Total
Waste Management	4'124	1'834	5'071	4'940		15'970
Post Operation Phase	475	319	455	460		1'709
Decommissioning	809	487	663	920	95	2'974
Total	5'409	2'640	6'190	6'320	95	20'654

While **Final Disposal of HLW** is a worldwide problem, current estimates of the cost of nuclear energy appear to consider that it represents a negligible share of the costs (See Figure 1 in chapter 3.1).

When the economic assessment for the construction of a nuclear power plant is undertaken, compared to other cost components, the issue of final disposal of radioactive waste and the costs incurred by it are hardly taken into account.

[24] Greenpeace (2013) considers the necessary storage time to be 250,000 years.

The reason is, as for decommissioning, the calculation method usually applied when taking investment decisions - the discounted cash-flow method:

Costs incurred at different points in time are calculated using the discounted cash-flow method for a set moment in time, e.g. the start-up of the NPP. This is done using "discounting". Future costs are calculated at a lower sum, which is calculated using the annual discounting rate. This method is based on the usually reasonable assumption that current income and expenditure weigh more heavily than future ones – funds which only need to be spent in the future should (at least theoretically) have already generated interest – this interest could be used to contribute to repaying the sum. (Böll 2010, Thomas 2010)

While this is the method usually applied for investment decisions, results with discount rates over long periods need be interpreted carefully: For example, costs of €1,000 discounted over 100 years, even if the discount rate was only 3%, would have a net present value of only €52. At highly discount rates, costs or benefits more than 15 years in the future have a negligible current value in a normal economic analysis (Böll 2010, Thomas 2010).

The choice of discount rate is essential for the calculated costs of capital, and operators of nuclear power plants usually try to apply higher rates than the real interest rates.[25] Using this method, the costs of final disposal can be made to look even smaller. Additionally, the assumed point in time at which the costs are to be incurred is significant. Thus the French capital value of the costs for final disposal is approximately the same as the German, although the real costs in France are around 68% higher. The reason is that the assumed payment time is set later. (Drasdo 2001, p. 20)

Because the investment for the final disposal of radioactive waste is due only many decades into the future, final disposal hardly receives any attention as a cost factor during the investment decision. The **cash-flow discount** method is a valid way for the investor to compare different investment options, however, to portray final disposal costs as insignificant easily leads to wrong conclusions, and can be **used to incorrectly imply that final disposal is "cheap".**

Not only the method of calculation, but also the best method of funding the disposal costs is uncertain. The operators of the facility are typically obliged **to take provisions from consumers** for the final disposal but how this money is kept varies widely. The most insecure method is probably where the company simply uses the provisions as investment capital so the 'fund' exists as a proportion of the value of the assets of the company. This relies on the company still existing when the provisions are required and that the assets prove to be worth their book value. However, if the cash-flow discount method is used then the amount is reduced significantly due to discounting. Whether **the costs will be covered at a future point** in time is **uncertain**. (Biermayr/Haas 2008, S. 34). It depends, amongst other things, on the assets be securely invested, the cost estimate being accurate, the assumed interest rate being achieved, the assumed timing being correct (if the money is needed earlier, it will not have accumulated enough interest).

[25] Most countries have some regulation and prescribe the discount rate or specify the investment type; very low risk, which means low interest rate. (Thomas 2014)

5.2 GENERAL INFORMATION ON DECOMMISSIONING

It is very difficult to estimate the costs for decommissioning (shutting-down) a nuclear power plant, because there is **very little expertise in decommissioning large nuclear power plants available worldwide.** However, some cost estimates assume that the decommissioning costs reach the level of the construction costs – i.e. in the range of several billion euros for a large NPP. (Schneider et al. 2011)

Here several estimates of the costs of decommissioning as quoted by different sources:

- The Swiss Nuclear Authority *Eidgenössische Nuklearsicherheitsinspektorat* ENSI gives the following costs for decommissioning in absolute terms as shown in Table 8 (ENSI 2012)
  - CHF 487 million for NPP Muehleberg (373 MW net) = **€ 399 million**
  - up to CHF 920 million for NPP Leibstadt (1190 MW net) = **€ 754 million**
- Maine Yankee, 790 MW_{el}: **US$ 616 million** in 2002 (Storm/Smith 2007, Part F, p. 49)
- Storm/Smith (2007) calculate costs of decommissioning reaching 100-400 % of construction costs (Part F, Table F.28) – based on the assumption that average construction costs of US$ 6,500 million for a 1,000 MW_{el} reactor (Storm/Smith 2007, Part F, p. 9) average costs of decommissioning of US$ 6,500 million – 26,000 million = approx. **€ 5 - € 20 billion**
- According to NEA estimates, the costs of decommissioning make up 10-15 % of the overnight capital costs
- El-Bassioni et al. (1980), whose results are the basis for EcoInvent (2009), calculate the energy used in demolishing a 1,000 MW light water reactor as ***75 % of the energy used in construction.***
  - Energy usage does not enable us to directly deduce the costs, but the figures give an idea of the dimensions.

It is clearly that even cost estimates more conservative than those calculated by Storm/Smith (2007) do not regard decommissioning as a small or negligible cost factor.

In contrast however, investment calculations often regard the cost of decommissioning as an almost insignificant small cost factor (approx. 1%, See Figure 1). However, the rules for the costs of fuel disposal (Chapter 5) apply equally to the costs of decommissioning:

As the costs of decommissioning are incurred only decades after start-up, the investment costs which need to be calculated are much lower than the sum which needs to be finally paid - therefore the figures are misleading when it comes to the absolute values.

Assuming that decommissioning will have been completed 150 years after start-up, and has been discounted at 3 %, then real term overall costs of **€ 1 billion** will cost **only € 12 million**. (Schneider et al. 2011)

An additional obstacle is that the real costs of decommissioning are very hard to foresee. All that is certain is that they will increase in time. At first glance, the current solution of paying into to a **decommissioning fund** seems to be a good one. However, the situation looks completely different when it becomes clear that the calculated payments were too low, or the fund's rate of return (interest) was lower than expected, or the operator went bankrupt before the end of the NPP's lifetime. All of these problems have occurred in the past years in the UK, and now a significant share of the decommissioning costs must be **borne by the taxpayer**. In the end, British Energy only had to pay £20 million per year, which is only 0.03 p/kWh because the rest of the costs were taken on by taxpayers (according to current exchange rate 0.035 Cent/kWh) (Thomas 2005, Böll 2010).

Other states use different systems for financing decommissioning costs: Some charge annual, non-discounted instalments of the final sum, and in Sweden and Finland the full, undiscounted amount has to be guaranteed at reactor start-up. (Wuppertal 2007)

An adequate estimate of decommissioning costs and the availability of the funds needed is extremely important: the European Commission has estimated that up to 48 reactors need to be decommissioned by 2025. (Wuppertal 2007)

Sample calculation

When, in 100 years' time, the costs of decommissioning a nuclear power plant reach **€ 700,000,000,** then, if discounted at 5%[26], this gives a calculated value of **€ 5,323,143 – only 0.8% of the real sum!**[27]

5.3 BULGARIA

5.3.1 GENERAL INFORMATION

Bulgaria has one nuclear power station with two units in operation and four units in different stages of decommissioning at **Kozloduy**, in the Northwest of the country.

Since 1957, different state bodies have been in charge of nuclear safety - the present **Nuclear Regulatory Agency (AyaR)** was established in 2002. The Nuclear Regulatory Agency implements the state regulation of the safe use of nuclear energy and ionising radiation and the safety of radioactive waste management and the safety of spent fuel management.

The General Department of Safety Regulation of Nuclear Facilities of AYaR assists the Agency chairman in the implementation of his regulatory and controlling functions with regard to activities at nuclear facilities, nuclear material and radioactive waste from nuclear facilities. The department is comprised of the following divisions:

- Division of licensing and control;
- Division of NPP resident control;
- Division of nuclear material and physical protection;
- Division of decommissioning and radioactive waste.

The functions of the Department are e.g. to prepare documents, summarize information, carry out analyses and prepare expert assessments related to the management of the Decommissioning of Nuclear Facilities Fund and the Radioactive Waste Management Fund.

[26] Note: In Drasdo (2001, p. 26) real interest rates of 1% p.a. to 13% p.a. are used.

[27] Calculations according to: http://www.zinsen-berechnen.de/renditerechner.php and own calculations using the discounting formula:
$K_0 = K_n * (1/(1+i)^n)$ simplified calculation, not including inflation; for comparison: discounting over 50 years at 5% would mean a final value of € 61,042,609, i.e. 9% of the real value.

The **State Enterprise Radioactive Waste (SERAW)** is a legal entity under Art. 62, para. 3 of the Commercial Act, established pursuant to Art. 78, para. 1 of the Act on the Safe Use of Nuclear Energy, having its headquarters in Sofia and specialized divisions across the country. Within it there are two directorates related to decommissioning and radioactive waste management:

- Decommissioning Directorate (DD) carries out activities on the decommissioning of nuclear facilities including Specialized Division Decommissioning–Kozloduy.

The Radioactive Waste Management Directorate (RAWMD) carries out radioactive waste management activities. It includes:

- the Specialized Division Radioactive Waste – Kozloduy (SDRAW Kozloduy);
- the Specialized Division Permanent Repository for Radioactive Waste – Novi Han (SD PRRAW Novi Han);
- the Specialized Division – National Repository for Radioactive Waste (SD NRRAW).

Two funds were established in 1999: The **Decommissioning of Nuclear Facilities Fund (DNFF**) and the **Radioactive Waste Management Fund (RWMF)**. The funds' money comes from the nuclear operators and other facilities that produce radioactive waste and is spent on the basis of year-to-year workplans. Funds are working also as co-funding facilities to EBRD's KIDSF[28].

Bulgaria also receives international support for closure of Kozloduy 1-4 units throughout the Kozloduy International Decommissioning Support Fund (KIDSF), managed by the EBRD. This mechanism, of funds like the KIDSF set up by the EU and other donors provides support for Bulgaria, Lithuania and Slovak Republic in return for them closing reactors characterised in the West as 'unsafe'. The money is delivered on a project basis, and is divided in two "windows" – a nuclear (decommissioning, RAW facilities) and a non-nuclear (energy efficiency and renewable investments) one.

5.3.2 CALCULATION OF THE PAYMENTS

We could not find out which **discount rates** were used in the calculation of the contributions to the funds – this information was neither available online nor did the MEE answer our question in this regard.

5.3.3 INCOMES AND EXPENDITURES OF DNFF AND THE RWMF

The following table shows the annual payments (for 2014) and the amount accumulated within the incomes/expenditures of the Decommissioning of Nuclear Facilities Fund (DNFF) and the Radioactive Waste Management Fund RWMF 2010-2013.

[28] Kozloduy International Decommissioning Support Fund (KIDSF) by the European Bank for Reconstruction and Development (EBRD)

Table 3: Income and expenditure of the Bulgarian DNFF and RWMF (source: Ministry of Economy and Energy (MEE), requested information by Green Policy Institute)

In EUR	DNFF (2010 - 2013)	DNFF (2014 budget)	RWMF (2010 - 2013)	RWMF (2014 budget)
Income	128,558,839.98	29,596,130.54	48,775,943.21	13,679,102.99
Total expenditures	2,258,928.43	n.a.	53,850,462.46	8,747,590.54
of which:				
Institutional costs	302,064.09	n.a.	320,510.47	0
Administrative expenditures	1,956,864.35	n.a.	53,529,951.99	8,747,181.50
of which:				
Running costs	841,984.22	n.a.	48,786,260.05	8,321,121.98
Capital costs	1,114,880.13	n.a.	4,743,691.94	426,468.56

The administrative expenditures of the DNFF go mainly to the Kozloduy NPP 1-4 closure projects, while RWMF administrative expenditures go mainly to SERAW, which invests in various radioactive waste facilities, incl. ones at Kozloduy NPP.

5.3.4 TOTAL COST OF DECOMMISSIONING

A presentation from ENPRO Consult (a private Bulgarian consultancy) made in mid-2011 (figures based on a report issued in 2006[29]) gives the following general information on the total costs of decommissioning:

- Preliminary assessment for the **costs of decommissioning** of Units 1-4 at "Kozloduy": **€ 352 - 880 million**.
- Decommissioning period **25 years** and **inflation rate – 3%**
- When decommissioning period and inflation rate are considered, the estimated costs go up to € 737 – 1842.5 million. The strategy for the management of spent nuclear fuel and nuclear waste until 2030 envisages a regular evaluation of the Kozloduy 1-4 blocks costing 500 million EUR. The expected future costs over 25 years are **1,047 million EUR**.
- The sum of the costs for the decommissioning of the Kozloduy 1-4 blocks for the period 2003-2037 is estimated to be € **1,117.610 million**, and for the period 2003-2020 € 842.025 million. This includes the money already spent between 2003-2009 which is € 276,067 million and the calculation shows planned spendings for 2021-2037 - 275,585 MEUR. This amount does not include:
  - Costs for decommissioning of facilities for processing and interim storage of RAW;
  - Costs for decommissioning of Spent Fuel Storage Facility.

[29] http://sofiaecho.com/2011/06/06/1101023_de-commissioning-of-kozloduy-npps-four-units-to-cost-11..., accessed on 28th Aug. 2014

5.3.5 TRANSPARENCY

Online Information

The most important online information sources are:

- institutional sources – SERAW, Kozloduy NPP, NRA, MEE, MinFin, MOEW
- non-institutional sources – media, pro-nuclear associations, individual blogs, etc.

In addition, some Russian sources also provide some information on Bulgaria-related nuclear issues. Sometimes official information was easier to find in international sources (e.g. IAEA, European Commission), rather than in Bulgarian ones.

We got the impression that some institutional websites changed their openness – e.g. they do not publish their yearly reports online any more (e.g. Kozloduy NPP) or only publish parts of them (e.g. SERAW). Surprisingly, EBRD has cancelled its nuclear web-page (http://www.ebrd.com/nuclear"www.ebrd.com/nuclear).

The usual approach towards information needed from officials is a procedure called "Public information request" – every citizen can request information over that channel. It takes around 2 weeks but often is prolonged by 2 more weeks or ends up at court.

During the entire process of data tracking for this report we had the impression that the nuclear authorities are not very generous with the provision of information. The tracking of information is not easy and requires expertise and the knowledge how to ask the rights questions.

The input for the following questions is available publicly and required only research of the Bulgarian legislation.

1. What is the status of the transposition of Directive 2011/70/EURATOM and what is the estimated deadline for transposing this piece of legislation?

> *Answer: \There are two Ordinances, issued by the Council of Min of Bulgaria that transposed Directive 2011/70/EURATOM: Ordinance on Safety in Radioactive Waste Management (23.08.2013) and Ordinance on Provision of Safety in Spent Fuel Management (amended 30.08.2013).*

2. What is the estimated cost of the deep geological repository for radioactive waste and what are the yearly amount set aside for its construction?

> No information

3. Which are the total sums estimated to be collected through the DF and WMF funds?

> No information

4. What are the regulations concerning compensations for persons from neighboring countries affected by a possible nuclear accident?

> *A chapter in the Law for the Safe Use of Atomic Energy is devoted to this issue. All in all it says that Bulgaria will use the provisions of the Vienna Convention. Affected citizens from countries that are not part of the Convention would be compensated only if there is an international agreement in force to which Bulgaria and the respective country are a part of or on the basis of the "principle of reciprocity".*

5. What is the regime of the DF and WMF funds? What is covered? Is this money reinvested? Does it accumulate interest? If it does, what is the interest rate?

Both funds are state-owned, managed by Executive Boards, both Boards are led by the Minister of economy and energy.

Area of covered activities:

- *Decommissioning:*
    - *the yearly programs of the license holder for decommissioning;*
    - *storage and burial of RAW that appears from decommissioning processes;*
    - *management of the DF;*
    - *others, incl. preparatory works for decommissioning.*
- *RAW:*
    - *the activities of SERAW;*
    - *other activities related to RAW management outside SERAW;*
    - *RAW-related R&D;*
    - *decommissioning of RAW management facilities;*
    - *management of the RAW Fund;*
    - *municipalities on the territories on which there is or will be (with all required permissions issued) a facility for RAW management. The total sum for such local projects is capped to 2% of the yearly budget of SERAW;*
    - *expropriation of private land for the national RAW storage facility.*
- *NOTE: It's explicitly written in the "RAW fund-ordinance" that the fund does not finance any remedy works from radioactive accidents on the territory of Bulgaria.*
- *No, [the money is not reinvested] the money is deposed at the Bulgarian National Bank (BNB);*
- *Yes [it accumulates interest];*
- *No answer was given on the interest rate.*

6. What are the discount rates are used for the funds?

No information

7. What is the rate of inflation considered for the calculation of the obligatory annual payments?

No information

8. What are the factors that might lead to an insufficiency of the funds?

There is only one main factor [that might lead to an insufficiency of the funds] – which is the lack of political will for realistic calculations.

9. What are the provisions in the case that the money put aside in the two funds do not cover the necessary amounts for decommissioning/waste management?

- *For decommissioning of nuclear facilities – in this case the obligations to cover the gap are with the last operator of the respective facility;*
- *For RAW– no provisions.*

5.3.6 CONCLUSIONS

In order to obtain specific information on the Decommissioning of Nuclear Facilities Fund (DNFF) and the Radioactive Waste Management Fund (RWMF), an extensive online research was carried out. Questions still open after this research were asked to the nuclear authorities in Bulgaria (the questions and answers are summarized above).

Nevertheless, the following questions could not be answered:

- How much money goes to different facilities (e.g. Low and Intermediate Level Waste repository or High level waste storage facility)?
- What are the total decommissioning costs per unit? SERAW and Kozloduy NPP still deny such information.

We could not get enough information to be able to estimate whether future payments into the funds will be sufficient to cover the estimated total costs. However, if such a gap occurred, it’s questionable whether Kozloduy NPP JSC (the state-owned company that operates Kozloduy NPP) would be able to cover the expected gap for decommissioning on its own. The state as sole owner would probably have to stand in.

In the meantime, the proponents of lifetime extension of units 5 and 6 at Kozloduy NPP or construction of new reactors (at Kozloduy or Belene) argue that longer lifetime and new reactors would allow Bulgaria to set aside more money for the future closure.

Text by Genady Kondarev, Za Zemiata

5.4 CZECH REPUBLIC

5.4.1 INTRODUCTION

At present, there are several hot nuclear energy issues in the Czech Republic: the update of the national energy strategy, the related plans for the construction of new nuclear units in Temelin and Dukovany and the extension of operation of the Dukovany nuclear power plant, which is nearing the end of its service life.

Funding, however, poses a major problem: As construction costs of recent NPP projects have skyrocketed, in 2013, ČEZ requested state guarantees in form of fixed electricity prices per kWh for the planned new nuclear units. Without such state guarantees ČEZ is not willing to build the new nuclear units in Temelin, also the plans concerning a new unit in Bohunice are on ice (see chapter 4.4.2).

The following text addresses another problem concerning finances and nuclear: the **funding for the deep repository for radioactive waste and decommissioning of nuclear power plants** - and the question whether or not the planned funds will be sufficient.

5.4.2 GENERAL INFORMATION

The responsibility for **handling radioactive waste** is assumed by the **Czech state** through the state enterprise **RAWRA** (Radioactive Waste Repository Authority, Czech: **SÚRAO**). All connected procedures are governed by the Czech Atomic Law, which is going to be amended in 2014.

NPP **decommissioning** is responsibility of the nuclear operator **ČEZ**.

Both processes are to be financed by the operator via payments in specific accounts – the necessary costs are budgeted within the electricity tariffs.

5.4.3 TOTAL COSTS AND ANNUAL PAYMENTS

The money for the construction of a deep repository for radioactive waste and for nuclear power plant decommissioning are collected in two separate accounts:

The so-called "**nuclear account**" was set up to finance the **construction of a deep repository** for spent fuel (an interim storage for spent fuel has already been built in Temelin and Dukovany by CEZ. This waste management fund account is managed by the Ministry of Finance. The operator ČEZ makes a yearly deposit of CZK 50 (~€ 1.82) for each MWh generated. For the current annual nuclear electricity production of about 28,600 GWh[30], this is an **annual payment of** CZK 1.43 billion (**€ 52 million**). At present, the account contains approx. CZK 20.5 billion (€ 740 million, as of November 2013) – payments started in 1988. The funds collected on the nuclear account intended for the construction of a deep repository will be used to cover the investment and operating costs and the sealing of the deep repository, which are estimated at CZK 110 billion (~€ 4 billion, estimated with 2012 prices, excl. VAT). The first construction work (first preparations, building of laboratory) will start in 2030, the main construction will start in 2050 - operation should start in 2065.

The funds on the nuclear account may be invested on financial markets in liquid state bonds, the Czech National Bank CNB, and securities of emitters selected by the Ministry of Finance (which also supervises the financing method and profitability). The revenue from these financial operations was CZK 558 million in 2012 (€ 20.3 million), a 15% increase compared to 2011.

The other account is the so-called "**fixed account**", on which money **for** nuclear facility **decommissioning** is collected; it is managed by the RAWRA and has been maintained since 2002. The annual payments into the decommissioning fund (DF) vary and are calculated according to the bill 360/2002. The payments are recalculated every 5 years and started in 1988. Estimated **total costs for decommissioning** are: Temelin: CZK 14.6 billion **(€ 0.53 billion**), Dukovany (estimation made in 2012): 22.4 billion CZK **(€ 0.81 billion**). It is not clear when the decommissioning will start for it is not clear when Dukovany and Temelin will be closed. But there are figures assuming the end of decommissioning will be Temelin 2088 and Dukovany 2085 (source: web SÚRAO)

[30] Status 2012 – according to http://www.iaea.org/pris/CountryStatistics/CountryDetails.aspx?current=CZ

5.4.4 CALCULATION OF THE PAYMENTS

According to SONS, a discount rate of **2.5%** is used for the calculation of the future investment price of the **waste management fund**, based on the current price level when the calculations are made.

5.4.5 ARE THE FUNDS SUFFICIENT?

There are doubts whether the funds on the nuclear account (intended for the deep repository construction) and the fixed account (intended for decommissioning of nuclear power plants) will be sufficient. According to the State Office for Nuclear Safety, such a situation cannot occur due to the system of levies. However, it's doubtful whether this answer is true: The **Supreme Audit Office** - after carrying out an audit that focused on financial resources and state property managed by RAWRA - **warned** in 2010 **that the money on the so-called fixed account will not be sufficient**, which may lead to future problems with the state budget. An official SAO representative stated: "Insufficient funding of the nuclear account will bring serious risks to the state budget as the state shall undertake the expenses for disposal of radioactive waste in case the financial reserves are not sufficient for disposal of radioactive waste"[31]

5.4.6 TRANSPARENCY

The primary sources of information on the handling of radioactive waste and decommissioning of nuclear facilities are the websites of the RAWRA, Ministry of Industry and Trade of the Czech Republic (MoIT) and the State Office for Nuclear Safety (EN: SONS, CZ: SÚJB). However, the information there is mostly one-sided. Alternative information sources are the websites run by Czech and international NGOs (e.g., www.temelin.cz, etc.).

Calla and South Bohemian Mothers (SBM) have approached the **SONS** (letter sent 19 Dec. 2013, reply dated 13 Jan) and the **MoIT** (letter sent 19 Dec. 2013) with **questions relating to the issues discussed above**. The questions were related to the potential deficiency of funds collected on the nuclear and fixed accounts and the method of handling the nuclear account funds on the financial market. Calla/SBM only received a reply from the SONS by the end of January 2014. Their reply indicates that the funds on the nuclear account may be invested on financial markets in liquid state bonds, the Czech National Bank CNB, and securities of emitters selected by the Ministry of Finance (which also supervises the financing method and profitability). In addition, the reply indicates that the SONS is convinced that the funds on both the accounts will be absolutely sufficient due to the system of levies.

The answers were only partially satisfactory as **SBM did not get answers to the following questions**:

- Why are the payments into the nuclear account still the same as in 1997 despite the estimates on the necessary investments being much higher now?
- If Dukovany and Temelin NPPs are closed earlier than planned, how will be the money for the nuclear account be brought up after this closure?
- How much money will CEZ have on the fixed account in 2025 (Dukovany NPP will be closed in 2025 in case there is no lifetime extension)? What percentage will the CZK 22.4 billion which are the estimated investments for decommissioning of Dukovany NPP be covered by then?

[31] http://www.nku.cz/en/media/insufficient-funding-of-the-nuclear-account-id5164/

Furthermore, no information was provided on what the annual payments into the **decommissioning funds** are made and what discount rate is used for the calculation of these payments.

Text by Monika Wittingerova, South Bohemian Mothers

5.5 HUNGARY

5.5.1 INTRODUCTION

In Hungary, one nuclear power plant with four reactors is in operation at the **Paks** site.

While lifetime extension is planned for the four units that were built in the eighties, building of two new units is planned at the site of the Paks nuclear power plant (see chapter 4.4.3). These plans endanger the use and spread of sustainable solutions within the energy system, partly due to the enormous costs of the new build project that would drain off all the financial sources that could be available for energy purposes in the country. At the same time, it is not clear what effects these plans will have on the funding of the decommissioning of Paks NPP and the management of radioactive waste. What can be stated is, that according to the system that was set up for financing these activities, the costs seem to be financeable, provided the estimates are accurate. When all units would be shut down prematurely, this matter will solely depend on the state budget.

5.5.2 GENERAL INFORMATION ON THE NATIONAL DECOMMISSIONING AND RAW FUND

The **Central Nuclear Financial Fund (CNFF)** was established in 1998, according to the Act on Atomic Energy (Act CXVI of 1996). CNFF is a treasury fund, which means that its budget with the annually planned expenditures and income is part of the state budget. In 1998, the Hungarian Atomic Energy Authority (HAEA) also established the Public Agency for Radioactive Waste Management (PURAM), for planning and implementing the activities concerning management of radioactive wastes and decommissioning of nuclear facilities. PURAM's activities are financed from the CNFF.

The minister in charge of supervising HAEA (currently this is the Minister of National Development) has always had the responsibility of supervising the CNFF. Until 2014, the manager of the fund has been HAEA, since then it has been the Ministry of National Development.

It is worth mentioning that there was no money allocated for waste management in the first 16 years of operation of the Paks NPP. For the total calculated expenditures of CNFF, see the following table.

Table 4: Total expenditures of the Hungarian CNFF until 2084 according to PURAM's 13th medium and long-term plan for the activities to be financed from the Central Nuclear Financial Fund, 2013

Total expenditures until 2084	
In millions of EUR, with VAT	
Bátaapáti LLW-ILW final repository	**351.04**
Research, construction, expansion	116.21
Operation	137.49
Conditioning	22.46
Shut down, monitoring	74.88
High level waste and SNF final repository	**2 343.42**
Preparation	211.73
Construction	910.71
Operation	1 011.83
Conditioning	-
Transportation	-
Shut down, monitoring	209.14
SNF interim storage	**400.77**
Construction, expansion	207.48
Renewal	3.85
Operation	189.44
Püspökszilágy LLW-ILW final repository (no NPP waste)	**156.08**
Safety enhancement	4.11
Shut down, monitoring	33.32
Operation	118.64
Decommissioning Paks NPP and SNF interim storage	**1 201.00**
Other costs	**936.48**
Compensation for municipalities	312.15
Fee of manager of the Fund	49.06
Fee for supervision	200.23
PURAM operation costs	375.04
Total	**5 388.79**

The plan – which does not include the planned new units at Paks – shows, that slightly more than **half of the CNFF** will finance the expenditures concerning **spent nuclear fuel**, and nearly a **quarter** will go be used for the **decommissioning** of the operating four units of Paks (see next Figure). As the Bátaapáti LLW-ILW final repository has been in operation phase since 2008, most of its costs do not appear in the plan.

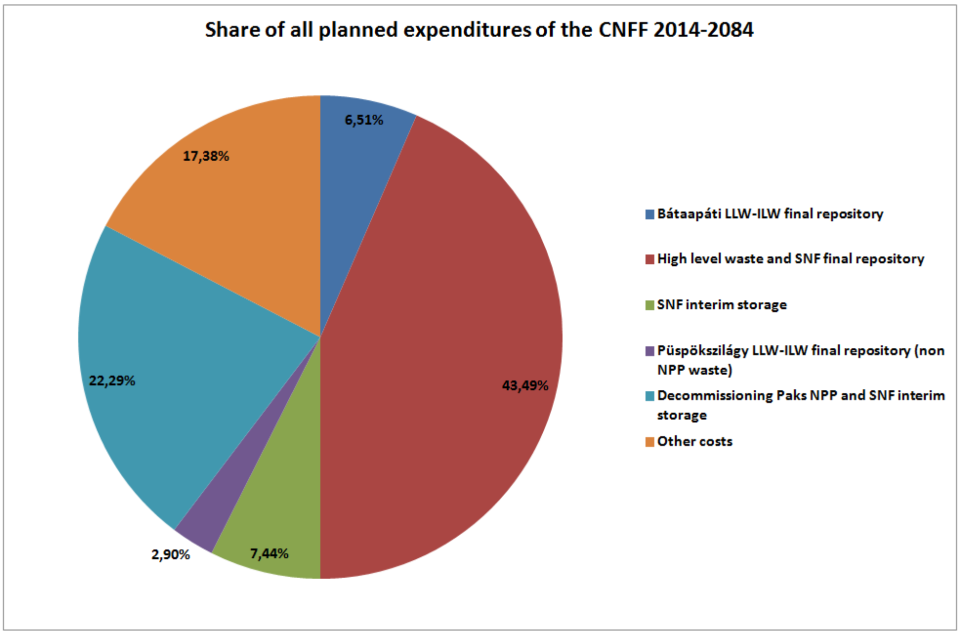

Figure 7: Share of all planned expenditures of the Hungarian CNFF

5.5.3 ANNUAL PAYMENTS

In 2014, the planned income of the fund is 32 172.9 million HUF (~103.8 million €), while the planned expenditures are 12,545.0 million HUF (~€ 63.3 millions) in 2014, so the sum in the **fund will increase by** 19 627.9 millions of HUF **(~€ 40.5 millions**). [32]

The **total amount in the CNFF** was 231,438.1 million HUF (**746.6 million €)** at the beginning of 2014. [33]

5.5.4 CALCULATION OF THE PAYMENTS

The CNFF's income is provided by the users of nuclear energy. The main contributor to the CNFF is Paks NPP which is obliged to accumulate the necessary financial resources to cover the costs of the management of the generated radioactive waste and it's disposal.

A table in the PURAM's 2013 intermediate and long term plan shows the planned incomes and expenditures of the fund until 2084, after that there are no planned expenditures to be financed from the fund. The income is determined by the yearly plans of PURAM. It should be noted that earlier plans calculated with operation of the fund until 2108.

The methodology of the calculations is supposedly based on an algorithm which was determined in 2000, by the Expert Committee of the then existing National Atomic Energy Committee, which is referred as "*Long-term Plan of*

[32] Values at 310 HUF/EUR

[33] Amount as the balance of the fund in 2013

PURAM for the Activities to be Financed from the Central Nuclear Financial Fund the Rules of the Required Cost Estimations" [34] (sic!).

The **interest rate** used for CNFF is **3%**, which is paid yearly out of the state budget. The rate will be reviewed in 2014, for the first time since the CNFF was established.

Inflation is taken into account when performing the annual planning, according to the yearly inflation figure given by the Hungarian National Bank.

Analysing concrete historical data, one can easily notice signs that question the foundations and the independence of the calculations. Numbers in the long term plans show partly **unexplained changes since 2005**. In the 2005 plan, while the planned payment of Paks for the next four years slightly decreased, an unprecedented increase appeared in the until-then more or less steady line of the planned target of annual payments for the years after 2010. This growth sharply increased further in the next years' plans. As at that time lifetime extension was not taken into account, this resulted in extremely high planned target of annual payments for the last years of the originally planned lifetime of the four units at Paks, especially in the 2008 and 2009 plans.

However, the actual payment never had to meet with these high figures, as beginning in 2010 the plan on the lifetime extension was taken into account, and the planned line of annual target payments changed to be being steady again. (See next figure)

[34] The 12th medium and long-term plan of PURAM for the activities to be financed from the central nuclear financial fund, may 2012

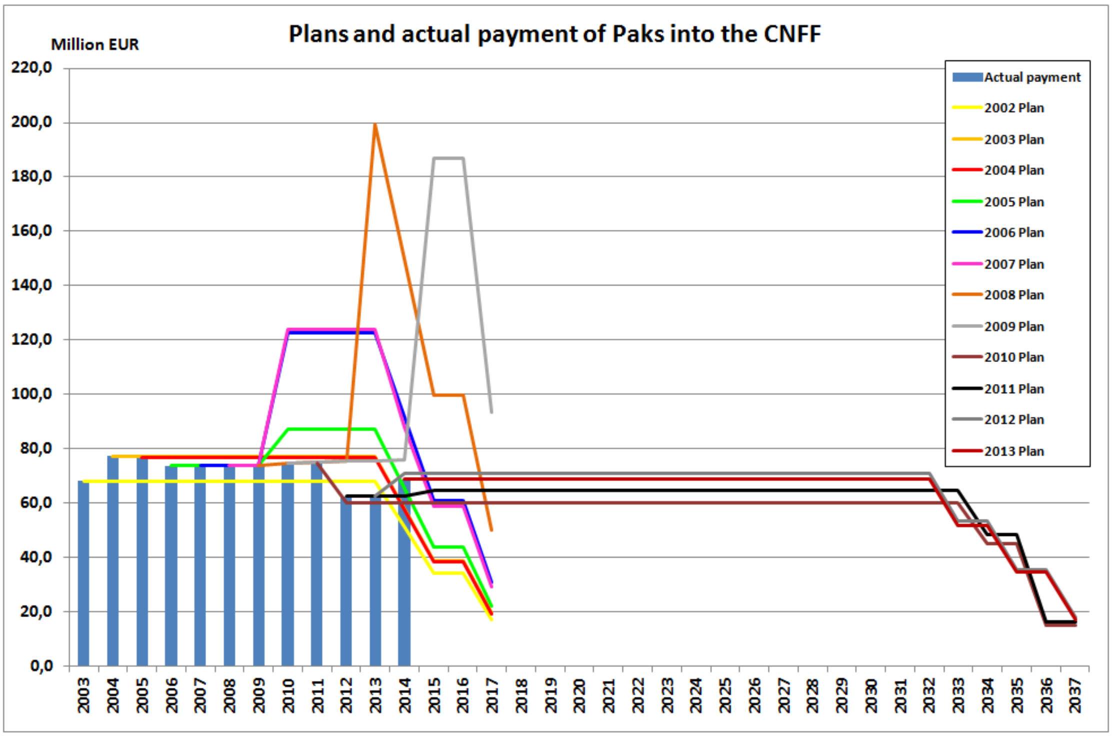

Figure 8: Mid and long terms of PURAM, 2002-2013

It is worth mentioning that plant **lifetime extension (PLEX)** was taken into account in calculating the annual payments although none of the units were licensed for PLEX at the time (and to date, only the first unit has got its PLEX license). While the total income of the CNFF, calculated on basis of the total operating time of the Paks NPP, significantly increased, the necessary annual payments slightly decreased. The high annual payments for 2012-2017, calculated in earlier plans, were not necessary anymore, due to the longer operating time.

It is also important to mention that PURAM is the body which makes calculations, but the minister supervising CNFF has the right to propose the final numbers concerning CNFF for the state budget. Last year this circumstance resulted in significant changes between **the numbers of the plan compared to the final numbers of the 2014 state budget**, as more than two thirds of the expenditures were cut back, and rather put into the accumulation of the fund. (See next figure). It is not known how these changes affect the long term plans of waste management and its financing.

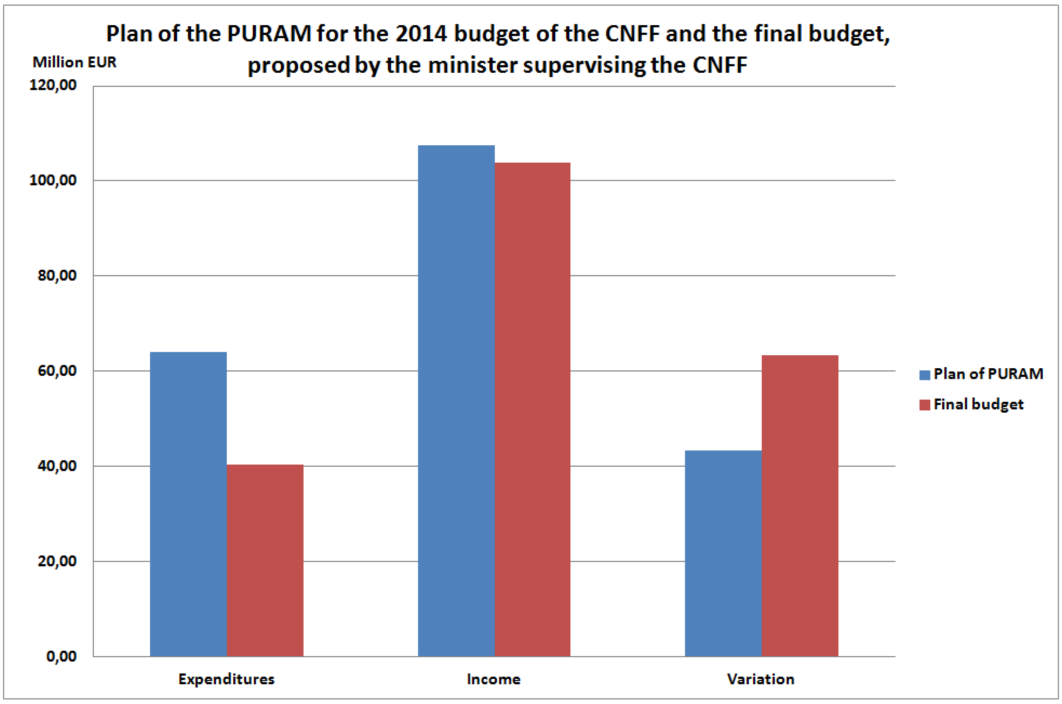

Figure 9: Plan of PURAM for the 2014 budget of the CNFF compared to the final budget proposed by the minister supervising the CNFF (diagram by author)

The reasons behind these changes are not clear, but for an independent observer it could seem that PURAM is biased in favour of the owners of Paks when performing calculations. With no official explanation, it seems that at a point, former plans concerning the costs of decommissioning and radioactive waste management proved to be wrong and calculations appeared to be insufficient. To correct the mistake, higher annual target payments were justified, which, with not taking into account the extended lifetime, had to be divided for only a short period of time and resulted in the high numbers for the last couple of years of the originally planned lifetime of Paks. This was economically impossible for the NPP, so firstly the target payments were postponed to 2012-2017, causing enormously high numbers. The issue could be settled only when PLEX was added to the picture, and the target could be spread over a longer period of time. It is worth to note at this point that in the middle of the 2000 years, the consequences of the serious incident of 2003 caused losses for Paks, but it is uncertain whether it has any relation to the matter.

Until the issue remains unexplained, the phenomenon clearly questions the method and thoroughness of planning future expenditures from the fund, as well as the independent operation of the PURAM.

As for the changes made by the minister concerning the 2014 budget of the CNFF, one could assume that it is related to the status of the state budget. As CNFF is a treasury fund, its income enriches the state budget. The so called “variation”, what is the annual growth of the Fund, practically could serve the other interests of the state budget.

5.5.5 SPECIFICATIONS

CNFF was established for financing the direct and indirect costs of the management of radioactive waste and spent fuel generated in Hungary (final disposal and in the case of spent fuel, interim storage also), and decommissioning (dismantling) of all nuclear facilities. CNFF is therefore designed to cope with these tasks not just for Paks NPP, but also for e.g. research reactors, interim storages of spent fuel, hospitals, and other research institutes etc.).

The operation of the CNFF is well established in the legal system. The most important rules are the Act on Atomic Energy (Act CXVI of 1996), and the Order of the Minister of Justice on the Operation of the CNFF (No. 14/2005. (VII.25)). Under this legislation, the Fund's money cannot be spent on purposes other than the tasks of the CNFF.

The tasks that are to be financed from the CNFF are within the state's responsibility. If the amount in the CNFF proves to be insufficient, the state is obliged to pay.

According to the recent status of CNFF, the satisfactory operation of the Fund is guaranteed only as long as there is a contributor, namely, a nuclear power plant.

It is unclear whether the state budget could cover the expenses in case there is no contributor to the Fund (as the NPP is shut down), but high expenditures appear year by year.

5.5.6 TRANSPARENCY

Transparency concerning the CNFF is satisfying. The webpage of the PURAM and HAEA contain most of the important information on the CNFF. The yearly prepared long term plans of the PURAM, the reports, the budget plans etc. are all quite easily available for internet users. Nevertheless, critics can be made - the table with the breakdown of the costs of activities financed from CNFF are mostly unreadable in the Hungarian electronic version of the long term plans. Interestingly, the English versions of the plans contain immaculate tables, so the numbers are eventually available.

The webpage of the Ministry of National Development (which became the manager of the fund instead of the HAEA this year) does not contain information on the CNFF yet.

As the information on the CNFF available online is sufficient, there was no need to ask further questions in written form. However, in the case of some details, requests aiming access to information could be necessary, as it has happened several times in the last decade (e.g. this way we could get the "Long-term Plan of PURAM for the Activities to be financed from the Central Nuclear Financial Fund the Rules of the Required Cost Estimations" some years ago). The answers of the HAEA and PURAM mostly proved to be satisfying.

5.5.7 CONCLUSIONS

The tasks that are to be financed from the CNFF are within the state's responsibility. If the amount in the CNFF proves to be insufficient, the state, ie taxpayers, is obliged to pay.

According to the recent status of CNFF, the satisfactory operation of the Fund is guaranteed only as long as there is a contributor, namely, a nuclear power plant.

It is unclear whether the state budget could cover the expenses in case there is no contributor to the Fund (as the NPP is shut down), but high expenditures appear year by year.

Text by András Perger, Energia Klub

5.6 POLAND

5.6.1 INTRODUCTION

Poland is the only country analysed in this report which has not operated nuclear power plants yet – but the government is planning to install nuclear capacity: A first NPP (comprising two reactors) is planned to be connected to the grid by 2025 and a second one (two more reactors) by 2035. Together, they would have a total electricity output of ca. 6 GW. Gathering from the cost estimates of 11 new nuclear plants under way in the US and Europe, the Polish administration assessed the **cost of the national nuclear energy programme** (Polish abrrev. **PPEJ**) at a range between € 9.5 billion and **€ 14.3 billion**.

Cost of nuclear power in Poland, even as early as during the current stages of planning and administrative preparations, pose a major problem as finding the total financing for the PPEJ will very likely be difficult according to the opinion of some experts from the financial, energy and academic sector. Possible construction of the NPPs would also severely burden the budget of the PGE (Polska Grupa Energetyczna), the company responsible for the future operation of the NPPs (listed at the Warsaw Stock Exchange; major shareholder is the State Treasury with 61.89%[35]). In spite of approving the official programme, the Polish government has no plans for a concrete financing model yet, but it is looking to subsidise the PPEJ heavily (despite the apparent contravention of EU state-aid legislation). Official calculations of Radioactive Waste Management (RWM), decommissioning and nuclear liability costs for PPEJ are assessed by a number of independent experts as underestimated and insufficient. Those costs have been communicated by the proponents of the nuclear programme as low in the mainstream media and touted by them as one of the advantages of this type of energy source over others, especially renewables. Such underestimated costs also make the predicted total costs of nuclear energy in Poland lower than seems reasonably probable and discussed by independent experts.

One research reactor of 30 MW(t) has been operated at the nuclear centre in the Swierk (near Warsaw) since 1974. There are 3 spent fuel facilities located there: one at the operated research reactor pond, the other two inside two other water ponds. (IPPA 2013)

5.6.2 GENERAL INFORMATION

Poland has to deal mainly with institutional waste generated from various applications of radioisotopes. Low and intermediate level radioactive waste (LILW) is produced at research reactors, scientific and educational institutions, hospitals and by the industry in Poland. Officially, the entire quantity is sent to the surface repository for LILW which is operated in the town Różan (in the central region of Poland). The capacity of this LILW surface repository is predicted to last only until 2020. Some amounts of high level radioactive waste (HLW) and spent nuclear fuel (SNF) have been generated by two research reactors: one in operation and one in the second phase of decommissioning. (IPPA 2013)

The radioactive waste generated today is managed by the ZUOP, a state enterprise which manages the present LILW disposal site, and is funded directly from the fees of its users (institutional customers) and by the state budget. The

[35] http://www.gkpge.pl/en/pge-group/governance, accessed 28 Aug. 2014

responsibility for handling future radioactive waste is assigned by law also to the **ZUOP** establishment (plant). The ZUOP is appointed by the Atomic Act to **manage both a deep repository as well as the new LILW disposal site, planned to be commissioned in 2020**.

The SNF from the research reactors, in line with international treaties (GTRI), has been sent 'back' to the Russian Federation as country of origin: six shipments were performed in the years 2010-2012. The next shipments of the SNF generated by the operated research reactor will be conducted when related agreements between the governments will be concluded. (IPPA 2013)

Although no **decommissioning** and RWM for HLW and SNF funds exist in Poland yet, there are already some concrete provisions in law which regulate the operation of such a future fund. Those **provisions** are made by:

- the Atomic law of 2011, specifically the paragraph no. 38d, point 8; and
- the Ordinance of the Government of 10 October, 2012 (which stems from the authoritization made in the Atomic Law) *[ref.: Rozporządzenie Rady Ministrów z dn. 10 października 2012 r. w sprawie wysokości wpłaty na pokrycie kosztów końcowego postępowania z wypalonym paliwem jądrowym i odpadami romieniotwórczymi oraz na pokrycie kosztów likwidacji elektrowni jądrowej dokonywanej przez jednostkę organizacyjną, która otrzymała zezwolenie na eksploatację elektrowni jądrowej].*

According to these provisions, the total sum for the **LILW disposal site would be ca. € 338.7 million, the HLW&SNF deep disposal site would be ca. € 4.40 billion**.

This ordinance contains one rule which defines the rate of the payment from every produced MWh of electricity at the given NPP to be made by its operator.

It has to be noted that the total payment should cover the costs of final management **both** of the spent nuclear fuel and of radioactive waste generated at all the NPPs operated in Poland so it visibly implies combining of the two issues **within one fund**.

There is no provision at this stage as regards to who or what type of institution shall be responsible for collecting the money from the payments. Both acts of the law use the wording "special fund" with a "dedicated bank account" to be "assigned to the fund" (point 1. of the Article 38d. of the Atomic Law). It is further interpreted, however, by the nuclear administration that it is the operator of the NPP which will own and manage this bank account. Whichever is the case, it will be controlled by the national nuclear regulator (PAA) through quarterly reports from the operator to the latter.

5.6.3 ANNUAL PAYMENTS

The payments are envisaged to be collected per MWh and they are set by the above mentioned Ordinance at the exact amount of 17.16 PLN / MWh (ca. € 4.10 per megawatt-hour). The specific annual payments could be calculated based on the total annual output of the NPPs but exact numbers for technical specifications are not known yet.

The factual payments shall be paid onto the dedicated account every three months.

5.6.4 CALCULATION OF THE PAYMENTS

For calculating the payments (per MWh) used in the ordinance, a special expert paper was commissioned. Its results and assumptions are extensively covered in the background text of this ordinance. **An inflation rate of 2% was used**.

5.6.5 SPECIFICATIONS

The fund will cover the costs of:

- disposal of all the SNF from all the complete operational lifetime of all the NPPs in Poland;
- disposal of the complete HLW and LILW produced in NPPs in Poland under the PPEJ (meaning the two ones built by 2035) during their whole operation lifetime;
- decommissioning of the NPPs, thus all the costs to be incurred in relation to the obtaining a decommissioning permit for those installations;
- management of the radioactive waste produced during the decommissioning of the NPPs and the interim storage tanks located at the NPPs.

The costs of managing radioactive waste produced from non-energy applications of nuclear technology has to be covered by the producers of that waste.

The money put aside for the fund can be held in long-term funds and is permitted to be used only for buying state treasury bonds and other so called 'secure financial papers' issued by the minister of finances.

If a **gap** between the amount of money saved in the funds and the actual money needed arises, it is the NPP's operator and ultimately electricity consumers or taxpayers who are liable to pay for it. In case of its insolvency it should be the operator's legal successor who will be held liable to cover the gaps. In case there is no successor the state is liable.

Here are the major assumptions concerning the **calculation of costs of future LILW management**:

- LILW produced during the whole life-time operation of an NPP will be processed and put in interim storage at the area of the NPP for a short-time (up to 3 years). The costs of this task shall be covered from the current expenditures of the NPP's operator (i.e. not from the decommissioning fund).
- For LILW a central LILW repository will be built. It will be designed to be expanded in stages so as to accommodate:
  - all radioactive waste produced during the whole operation life-span by all the NPPs operated in Poland under the PPEJ [Note: the ordinance was passed when the first draft of the PPEJ was approved by the Ministry of Economy with 2030 as the year of starting the second NPP. In the later version of the PPEJ approved (this time by the government) this date was postponed until 2034 but the ordinance was not updated in relation to this fact according to the information we could acquire];
  - the whole radioactive waste produced during decommissioning of all the NPPs;
  - remaining RW from non-energy use of nuclear technologies in Poland.
- Costs of building, operating, monitoring, closing of the LILW repository as well as post-closure supervising and monitoring will be covered by “the payments for LILW disposal”.
- The operation costs include the compensation fees paid to the budget of the gmina (lowest state's administrative unit) in which the LILW repository would be sited.

For storing **spent nuclear fuel** (SNF) **interim storage tanks** (ST) are to be built at every NPP to allow for accommodating all the SNF coming from the entire operation life-time of the NPP. Costs of building and operation of ST for SNF would be covered by the NPP's operator until obtaining a permission for starting the decommissioning.

For storing HLW and SNF, a deep repository is envisaged to be constructed.[36] Its capacity would have to accommodate HLW and SNF from the whole life-time operation of all the NPPs, i.e. **7000 tons.** The storage tanks' are planned to start operation 10 years after unloading the fuel from the reactor core for the first time (2064). As in the case of LILW, entire cost of building, operating, monitoring, closing of the LILW repository as well as post-closure supervising and monitoring will be covered by "the payments for repositing of HLW and SNF". The operation costs include also a compensation fee paid to the budget of the gmina in which the deep repository would be sited.

5.6.6 TRANSPARENCY

The basic official sources of information on radioactive waste management in Poland, i.e. web-pages of the Ministry of Economy (MG), Polish Atomic Agency (PAA) or Radioactive Waste Management Plant (ZUOP) contain details on various technical aspects of the present management of RAW and on the law in place but none of them discusses economics of radioactive waste and the details covered in this report.

The web-pages of the IAEA and NEA:

- http://newmdb.iaea.org/REPORTS.ASPX
- https://www.oecd-nea.org/rwm/profiles/
- https://www.oecd-nea.org/jointproj/decom.html

are partly outdated.

However, most of those details are discussed in the reasoning (justification) part of one draft legal act, namely the ordinance of the Council of Ministers of 10 October, 2012. It can be found on the Polish state's Internet legislative base but with some substantial effort. Thus information on RAW and decommissioning issues is not easy to find. Other information than that is only available over a public information act request.

We were able to get answers to the following questions by our request the PAA agency (Polish Atomic Agency) in 2014. What are the provisions on how the money put aside for the fund can be used for?

1) What happens if a gap between the amount of money saved in the funds and the actual money needed arises? Who is liable to pay for it?
2) What type of institution operates the fund?
3) We would like to receive the original expert paper used to calculate the payments.
4) When will the Ordinance will be updated considering it was adopted before the adoption of the previous version of the PPEJ?

Text by Marcin Harembski

[36] There are no firm, or even distant plans about building such a repository in Poland but the calculations were made with specific assumptions regarding general technical data.

5.7 ROMANIA

5.7.1 GENERAL INFORMATION

In Romania, one nuclear power plant is in operation - at the Cernavoda site one unit has been in operation since 1996 and a second unit since September 2007.

The **Nuclear Agency & Radioactive Waste (ANDR)** was established in 2009 as a consequence of the law 329/2009, by fusion of two agencies - the Nuclear Agency (AN) and the National Agency for Nuclear Waste (ANDRAD).

The current ANDR is responsible for managing the nuclear decommissioning fund and radioactive waste management fund. The funds are regulated through Governmental Decision no. 1080 from 5 September, 2007, regarding the setup and management of financial resources necessary for the safe management of radioactive waste and decommissioning of nuclear and radiological installations. The Governmental Decision reviewed the contributions and stipulates the creation of **two segregated funds** with the following purpose: one for **decommissioning** of the nuclear units and another for **spent fuel and radioactive waste disposal**, which includes the costs for construction, operation and closing of both a final repository for Low and Intermediate Level Waste at Saligny and a deep geological repository.

Other provisions within the national law stipulate that the **nuclear license holder pays** the contribution to both funds and has to ensure that the appropriate material and financial arrangements are in place for decommissioning by the time they are needed: The regulations GD 1568 /2003; GD 1575/2004 and GD 2379/2005 regulate the financial annual minimum contribution of the main generators of radioactive waste, based on the principle "polluter pays".

5.7.2 TOTAL COSTS

The total **decommissioning** costs for each nuclear reactor in operation are estimated at 247 million Euros **(€ 494 Mio. for the two existing reactors**, estimation from 2006). Normal operational lifetime for a CANDU6 reactor is 30 years, so decommissioning for the 1st unit at Cernavoda is planned for 2027 and 2038 for unit 2, according to a statement by the President of NuclearElectrica. There is a possibility that they might extend the operational lifetime for both units. The fuel-containing pressure tubes have to be replaced after 20-25 years. This has been done in Canada but it is close to being a reactor re-build and is expensive, problematic and has generally been late and over-budget. After 20-25 years, it cannot be assumed the pressure tubes will not fail leading to a serious incident and if the tubes are not replaced the reactor ought not to be licensable. Re-tubing generates a significant quantity of ILW (Thomas 2014)

On the other hand, the cost to setup up a **LILW** (Low and Intermediate Level Waste) **repository** at Saligny, in the immediate vicinity of the Cernavodă NPP, is estimated at **€ 452 million**, excluding VAT for four units (estimation 2006). ANDR is waiting for the emplacement and construction authorizations for the Saligny LILW repository. Construction should start in 2016 and operation of the first 8 cells in 2019.

Concerning the construction, operation and closing of a **deep geological repository** as a final storage facility for HLW (High Level Waste), the total investment was estimated at 510 million dollars per decommissioned unit back in 2006 – for HLW from the 4 expected units at Cernavodă. In 2009, the president of ANDR declared for a newspaper article that the geological repository would cost between € **2.88 and 4.4 billion**.

5.7.3 ANNUAL PAYMENTS

The legislation (GD 1080/2007) states that SN Nuclearelectrica SA, the main contributor to both funds, has to pay a levy on energy production at a rate of **0.6 euro/MWh for the Decommissioning Fund (DF)** and **1.4 euro/MWh for the Waste Management Fund (WMF)**. The payment is made in equal monthly tranches.

Table 5 shows the annual (2012) contributions of NNS to both funds at the end of the reporting year according to ANDR's 2012 annual report. These contributions include contributions for decommissioning and setting up, operating and closing LILW and HLW repositories. The actual 2012 contribution of the company according to this data are approx.: € 6.97 million for the Decommissioning Fund and **€ 16.19 million to the Waste Management Fund.**

Table 5: 2012 contributions and interest accumulated for DF and WMF

No. Crt.	Name of the Funds	Value RON / EUR (est.)
1	**Waste Management Fund** total, of which:	**72 869 592 / 16 193 242**
1.1	Contributions for safe management of radioactive waste produced from operating from operating and decommissioning of Unit 1 at Cernavodă NPP	31 621 028 / 7 026 895
1.2	Contributions for safe management of radioactive waste produced from operating from operating and decommissioning of Unit 2 at Cernavodă NPP	35 497 219 / 7 888 270
1.3	Income from interest in 2012[37]	5 751 345 / 1 278 076
2	**Decommissioning Fund** total, of which:	**31 349 428 / 6 966 539**
2.1	Contributions for decommissioning Unit 1 at Cernavodă NPP	13 559 605 / 3 013 345
2.2	Contributions for decommissioning Unit 2 at Cernavodă NPP	15 205 318 / 3 378 959
2.3	Income from interest in 2012	2 584 505 / 574 334

[37] This is the interest for the whole income of ANDR in 2012, not only the sums mentioned in the table.

The following table shows how much money has already been collected within the funds:

Table 6: Situation of the funds constituted at Trezoreria Sector 1 Bucureşti, at 31st of December 2012 (source: annual report 2012 ANDR)

No. Crt.	Name of the Funds	Value RON / EUR (est.)
1.	**Safe management of radioactive waste resulted through operation and decommissioning of each nuclear unit and final storage of radioactive waste generated,** of which:	**329 539 089 / 73 978 917**
1.1	Unit 1 at CNE Cernavodă	166 752 207 / 37 434 550
1.2	Unit 2 at CNE Cernavodă	162 786 882 / 36 544 366
2.	**Decommissioning of each unit,** of which:	**148 302 949 / 33 292 838**
2.1	Cernavoda U1 NPP	77 956 501 / 17 500 617
2.2	Cernavoda U2 NPP	70 346 448 / 15 792 220
	TOTAL Funds	**477 842 038 / 107 271 756**

5.7.4 CALCULATION OF THE PAYMENTS

The basis for calculation of the obligatory annual payments does not appear on any website of the Romanian regulating authorities nor in the answers to Romanian NGO TERRA's information requests sent to ANDR. What we know so far is that **inflation rates** are not taken into account for the calculation of the obligatory annual payments.

As shown in Table 1, both funds accumulate interest in accordance with the law and **interest rates** established by the Romanian National Bank. TERRA did not get an answer on the interest rates applicable. The following information can give an idea on the interest rate: When the new authority (ANDR) was set up in 2009, it had the amount of 176,897,044 lei in its accounts - the amount of 5,262,763 lei represents the interest for the deposits after discounting (3,29%). ANDR is using a deposit at the State Treasury with interest capitalization every 3 months.

Extensive research into the matter uncovered some irregularities regarding the review of the proposed amounts of the annual contributions. As we have shown, the amount of the contributions to both funds is 2 EUR/MWh. This amount was established through a Governmental Decision (GD) back in September 2007, based on 7 national and international studies. The same GD stipulates that the amount of the **contributions should be revised after a maximum of 5 years**, **yet the deadline for the revision has passed**. ANDR's 2012 report mentions that this revision is supposed to take place in 2014, after an actualization of decommissioning and long-term radioactive waste management costs in 2013.

In conclusion, **none** of the websites of the regulatory or state authorities give any **clear statement about how** the **calculation base** for the contributions to the two funds is **established**. The only document that gives a hint about this is an Explanatory Note to GD 1080 from 2007, which mentions 7 studies as reference for the establishment of the level of contributions. None of these studies is publically available on the web.

5.7.5 ARE THE FUNDS SUFFICIENT?

Both, the DF and WMF, are destined exclusively for decommissioning of nuclear reactors and the management of radioactive waste and spent fuel, including the cost of setting up, operating and closing a high level waste deep geological repository.

ANDR is using the two funds for purposes exclusively related with decommissioning or waste management. The money set aside in these bank deposits is not reinvested; it only accumulates interest according to the legislation.

Should a **gap** arise between the amount of money saved in the funds and the actual money needed, the law stipulates that the **Romanian state is liable for paying the difference**. This only happens after the operator proves that it cannot cover the expenses (e.g. insolvency).

5.7.6 TRANSPARENCY

A. Online Information

The main information source concerning the RadWaste/Decommissioning funds is ANDR's website. One can also find similar or additional information on the nuclear regulator's website, CNCAN, and the operator's website NuclearElectrica S.A..

Gathering most of the information researched is a painstaking process of digging through the national legislation. ANDR's website mentions the existence of supporting documents, but does not offer links to these documents, nor can they be found anywhere else on the web. Most of the website gives out information for first time readers, but does not offer more comprehensive literature, except for legislation, public acquisitions and ANDR's annual report. All in all, the most important information can be found within the relevant legislation.

Most, but not all of the questions which resulted from the discussions within the Joint Project could be answered. Exceptions are the calculation for the obligatory annual payments including the interest rate and the costs for a geological repository: It was not really explained how the calculations were carried out and the cost for the geological repository mentioned above (taken from a newspaper article) gives a very wide margin. It is important to note that the estimated costs for decommissioning and dealing with the radioactive waste resulted from the operation Cernavoda NPP in 2006.

B. Questions to ANDR

In the following, the answers to questions sent to the regulatory authority, ANDR are shown:

1. What is the status of the transposition of Directive 2011/70/EURATOM and what is the estimated deadline for transposing this piece of legislation?

> *Answer: Information regarding the status of the transposition of the Directive is available at http://www.cdep.ro/pls/proiecte/upl_pck.proiect?cam=2&idp=13689.*
>
> [comment by the author: The transposition has been finalized on the 23rd of December 2013 - Law 378 from 2013]

2. What is the estimated cost of the deep geological repository for radioactive waste and what are the yearly amount set aside for its construction?

3. Which are the total sums estimated to be collected through the DF and WMF funds?

Answer 2 and 3: According to the Explanatory Note associated with GD 1080/2007, the total cost estimated in 2006 for decommissioning and recovering the site of a nuclear unit, out of the 4 at Cernavoda, was approx. 980 mil. $, amount broken down as follows:

- effective decommissioning: 320 mil $;

- constructing, operating and closing a final deposit for spent nuclear fuel and high level waste: 510 mil $;

- constructing, operating and closing a final deposit for low and medium radioactive waste: 150 mil $.

This information is available at www.gov.ro. [comment by the author: There was no such information on this homepage by January 30th 2014]

The calculation for the sums deposited annually by the radioactive waste generators for the construction of the deposit are regulated by GD 1080/2007, regarding the manner for establishing and managing of the financial resources necessary for the safe management of radioactive waste, found on ANDR's website at www.agentianucleara.ro.

4. What are the regulations concerning compensations for persons from neighboring countries affected by a possible nuclear accident?

Answer: Regulations regarding liability and the compensations granted in case of a nuclear accident are not ANDR's jurisdiction.

5. What is the regime of the DF and WMF funds? What is covered? Is this money reinvested? Does it accumulate interest? If it does, what is the interest rate?

Answer: According to GD 1080/2007 regarding the manner for establishing and managing of the financial resources necessary for the safe management of radioactive waste, the financial resources [are] accumulated in the accounts provided on Art. 6, line 4 opened at State Treasury.

The funds used by ANDR are funds with a specific destination which cover expenses on activities stipulated in GO 11/2003, modified, legislative act available on ANDR website, at www.agentianucleara.ro. These funds accumulate interest according to the law.

6. What are the discount rates are used for the funds?

Answer: Concerning discount rates, we want to make clear that this banking term is no longer being used since 01.02.2002, the Romanian National Bank using the term benchmark interest rate. [comment by the author: The question was not answered, probably because it was not understood by the person in charge of responding to the information requests. Benchmark interest rates are not the same as discount rates.]

7. What is the rate of inflation considered for the calculation of the obligatory annual payments?

   *Answer: The obligatory annual payments are made in conformity with GD 1080/2007, **without taking into account the inflation rate**.*

8. What are the factors that might lead to an insufficiency of the funds?

   Answer: The main factor that could lead to an insufficiency of the funds is early decommissioning of a nuclear unit at Cernavoda.

9. What are the provisions in the case that the money put aside in the two funds do not cover the necessary amounts for decommissioning/waste management?

   Answer: Information regarding the responsibility for safely depositing radioactive waste and decommissioning the nuclear installations at Cernavoda, implicitly from a financial point of view, can be found in GO 11/30.11.2003 regarding the safe management of radioactive waste. This piece of legislation is also available on ANDR's website, at www.agentianucleara.ro.

A second letter was sent, asking for clarifications on discount rates and the estimated cost of the deep geological repository. The answers were yet again avoided.

The first information request was sent on the 26 November, 2013 - it was answered by the 6 December, 2013. The second letter was sent on the 20 January, 2014 and the answer arrived on January 28th.

Analyzing the answers given by the regulatory authority, there are few exceptions where ANDR has given straight answers to question, whereas in most instances we were being referred to the legislation or the answer is eluded altogether as is the case for the estimated cost of a geological repository, discount rates used or interest rates applicable. A second information request asking for answers/clarification as regards the estimated cost of a geological repository and discount rates used met with the same referral to the national legislation or copy/paste answers from the legislation in question.

5.7.7 CONCLUSIONS

After evaluating information on the decommissioning and radioactive waste funds available online and additional information on the subject given by ANDR, the following topics **could not be clarified**:

- calculation method of the obligatory annual payments including the interest rate
- estimated cost of a geological repository

Furthermore, some **shortcomings** were discovered:

- Inflation rates are not taken into account for the calculation of the obligatory annual payments.
- The amount of the contributions to both funds (2 EUR/MWh) should be revised after a maximum of 5 years, yet the deadline for the revision has passed: ANDR's 2012 report mentions that this revision is supposed to take place in 2014, after an actualization of decommissioning and long-term radioactive waste management costs in 2013, which hasn't happened so far.

Regarding **transparency**, it is difficult to find precise information. It seems that the authorities are answering mainly to demonstrate that they are fulfilling their obligation according to the law but at the same time they are giving the minimum information possible or avoiding the answer altogether. Comparing the information received by TERRA III to various public information requests including requests by the Parliament (e.g. answer received by Mr. Deputy Dumitru Chirita to his interpellation into the Parliament) we can see that public information requests from the public and the Parliamentare treated differently.

Text by Lavinia Andrei and Mihai Stoica, Terra Mileniul III

5.8 COMPARISON

	BG	CZ	HU	PL (Plans)	RO
Installed operating capacity (gross electrical capacity)	2000 MW	4112 MW	2000 MW	Plans for 6000 MW, no installed capacity yet	1411 MW
Decommissioning					
Total costs of decommissioning	€ 352-880 million € 737–1842.5 million incl. inflation over 25 years	Temelin: € 530 million (CZK 14.6 billion) Dukovany: € 810 million (CZK 22.4 billion)	Decommissioning of Paks NPP (4 reactors) and SNF interim storage: € 1,201.00 million (total expenditures until 2084)		€ 494 million for both reactors (estimation from 2006)
Total costs of decommissioning/MW	€ 93,617.02–234,042.55/MW € 196,010.64-490,026.60/MW incl. inflation over 25 years	€ 303,717/MW	€ 600,500/MW		€ 350,106/MW
Annual payment in the fund	29,596,130.54 (year 2014)	payments are recalculated every 5 years	~€ 103.8 million in 2014 for RAW disposal and decom.		€ 6.97 million in 2012
Annual payments in the fund per MW or MWh	€ 14,798/MW		€ 51,900/MW for RAW disposal and decom.	€ 4.10 per MWh (PLN 17.16/MWh) for RAW disposal and decom.	€ 0.6/MWh
Accumulated funds	Decom. fund established in 1999	current decom. fund established in 2002, payments started in 1988	€ 746.6 million at the beginning of 2014 (HUF 231,438.1 million) in the CNFF (for RAW disposal and decom.)		
start of decommissioning		start unclear, depending when Dukovany/Temelin will be closed; end of decommissioning could be			unit 1: 2027 unit 2: 2038

		2088 (Temelin) and 2085 (Dukovany)			
RAW disposal					
Total costs of RAW disposal	unclear	€ 4 billion excl. VAT (2012 prices) (CZK 110 billion) for the construction, operation & sealing of a deep repository for spent fuel	Bátapáti LLW-ILW final repository: € 351.04 million incl. VAT HLW and SNF final repository: 2,343.42 million incl. VAT SNF interim storage: € 400.77 million	total costs for LILW disposal site: € 338.7 million total costs for HLW&SNF disposal site: € 4.4 billion	LILW repository at Saligny: € 452 million excl. VAT deep geological repository for HLW (construction, operation, closing): € 2.88 - € 4.4 billion
Total costs of RAW disposal per MW	unclear	€ 972,763/MW of currently installed capacity	Bátapáti LLW-ILW final repository: € 175,520/MW incl. VAT HLW and SNF final repository: 1,171,710/MW incl. VAT SNF interim storage: € 200,385/MW	total costs for LILW disposal site: € 56,450/MW total costs for HLW&SNF disposal site: € 733,333/MW	LILW repository at Saligny: € 320,340/MW excl. VAT deep geological repository for HLW (construction, operation, closing): € 2,041,105/MW - 3,118,355/MW
Accumulated funds	RWM fund established in 1999	€ 740 million as of Nov. 2013 (CZK 20.5 billion) payments started in 1988	€ 746.6 million at the beginning of 2014 (HUF 231,438.1 million) in the CNFF (for RAW disposal and decom.)		
Annual payments in the RAW fund	13,679,102.99	€ 52 million per year for 28,600 GWh (CZK 1.43 billion)	~€ 103.8 million in 2014 for RAW disposal and decom.		
Annual payment in the fund/MW or MWh	(based on 2014)	~€ 1.82/MWh per year (CZK 50/MWh)		€ 4,10 per MWh (PLN 17.16/MWh) for RAW disposal and decom.	€ 1.4/MWh for the Waste Management Fund WMF)
Calculations					

Interest rate/discount rate	unclear	2.5% discount rate for calculations	3% (will be reviewed in 2014)		funds accumulate interest established by the Romanian National Bank
Inflation considered	3%		inflation is considered, yearly inflation rate of the Hungarian National Bank		no

6 COSTS OF NUCLEAR ACCIDENTS AND LIABILITY

The largest accidents of nuclear power plants until now took place in Chernobyl (Ukraine) in 1986 and in Fukushima (Japan) in 2011. Those two Beyond Design Basis Accidents (BDBA) cause a major release of radioactivity from the destroyed reactors and a long-term damage to people and nature and thereby also to the economy and the political system. The situation at Fukushima is far from stable and the difficulties of accessing the site means it is too early to quantify the extent of the damage.

This Chapter first describes the potential amount of cost of such severe accidents (BDBA). In the next step those costs will be compared to the currently applied liability sums for the nuclear operators to examine, to which extent they could cover maximum damage.

6.1 COSTS OF SEVERE ACCIDENTS

6.1.1 CHERNOBYL

The severe accident at Chernobyl 1986 affected approximately 9 million people of those were 3 million children. The value of human life and the suffering caused cannot be offset with money – the monetary assessment therefore only includes impacts that can be monetized. The following overview of long-term consequences that can be translated into monetary terms however gives an impression of how far-reaching the impacts of severe accidents can be.

Ukraine and Belorussia, both then parts of the Soviet Union, had to establish special ministries to manage the disaster. According to WHO[38] data, both states and Russia lost 17843.2 km^2 of their agricultural land and 6942 km^2 of forests with economic use. Agricultural and processing companies as well as factories, whose resources (wood, minerals etc.) had been contaminated needed to be closed down.

The Chernobyl Forum, an initiative of international organizations[39] and of the three mainly affected states Belorussia, Ukraine and Russia devoted one chapter of its final report to the socio-economic consequences (Chernobyl Forum 2006): The range of costs which had occurred in these countries for two decades **were estimated at hundreds of billions US$, for 30 years for Belarus alone at 235 billion US$**[40]. More precise estimates are not possible, because the Chernobyl accident accelerated the break-up of the then Soviet Union, its consequences being years of insecurity and new orientation of the economic and financial system.

Hundreds of thousands of people needed to re-settle from the contaminated areas, tens of thousands of houses and apartments had to be newly build, as well as schools for the children and other infrastructure. For treatment of affected people hundreds of hospitals and outpatient clinics had to be constructed and

[38] http://www.who.int/mediacentre/news/releases/2005/pr38/en/index1.html, accessed: 15 April 2013

[39] IAEO, WHO, UNDP, FAO, UNEP, UN-OCHA, UNSCEAR; World Bank Group

[40] For comparison: The current Austrian budget amounts to 73 billion euro, corresponding to 96 billion US$ (exchange rate April 2013). Belarus has an area of 207,600 km^2, this is 2,5 times the area of Austria, while the population of 9.5 million is only about 10% higher than in Austria.

drugs made available on a long-term basis. This was not possible without international help. e. g. the thyroid centre of the German radiobiologist Edmund Lengfelder´s Otto Hug Radiation Institute which was opened in Gomel/Belorussia in 1993.[41]

In large parts of the country the demographic situation shifted, young people and children were resettled or migrated, the birth rate sank and mainly old people were left behind. This also reduced the workforce and poverty in the affected regions, mainly rural areas, worsened.

In the first years after the catastrophe, Belarus had to spend up to 20% of its annual budget for the minimization of the consequences. The damages in Ukraine and Russia are slightly smaller, because smaller regions were affected. In 2006, ***20 years after the catastrophe, Ukraine still had to dedicate up to 7% of the annual budget to deal with the consequences.*** A large part of the budget needed yearly goes to social support for over seven million people who are affected in the three states (Chernobyl Forum 2006).

6.1.2 FUKUSHIMA-DAI-ICHI

25 years after the disaster in Chernobyl another accident with large releases occurred: In March 2011, in the Japanese NPP Fukushima-Dai-ichi multiple problems including core melt-down and the release of radioactivity followed a heavy earthquake and a tsunami.

The accident showed that a severe accident can occur anytime: NPP operators claim, as a result of Probabilistic Risk Assessment (PRA) the accident probability is 10^{-6}, or once in a million years per plant. However, it is clear that this probability is a large underestimate and values coming from PRAs are only useful to enable a comparison of different plant designs. Severe accidents can never be completely excluded and can occur also at modern reactors. In the following chapter a short overview of consequences of accidents and some early cost estimates will be provided:

From the area surrounding the multiply destroyed NPP (800 km^2, the so-called „exclusion zone") about 160,000 people were evacuated, about. 50,000 more left their homes voluntarily. (Greenpeace 2012, 2013). It is not clear yet, how many of them will be able to return. The costs of buying up of the abandoned land, compensation for the affected people (over 10 years) and the decommissioning of the reactors [42] is supposed to cost between **71 and 250 billion US$** (JCER 2011a). The compensation costs offered by the meanwhile nationalized operator TEPCO however are far from sufficient according to Greenpeace reports (Greenpeace 2012, 2013). Payments for farms and fishing industry are not included. Some of the affected people filed law-suits, the outcomes of which are not yet known. McNeill (Greenpeace 2012, p. 32) bases his cost estimates also on the data provided by the Japan Center for Economic Research (JCER 2011b, p. 3). This source shows a figure on the annual average costs for decommissioning, compensation and recovery of all areas with a level of contamination leading to a dose of over 1 mSv/a in a diagram. McNeill based a calculation of total costs on it resulting in ***520-650 billion US$*** (40-50 trillion yen).

[41] http://www.ohsi.de/hilfsmassnahmen-in-belarus/diagnostik-therapie/, accessed: 16 April 2013

[42] based on costs of decommissioning the accident reactors in Chernobyl/Ukraine and Three Mile Island/U.S

6.1.3 SCENARIO FOR FRANCE

The French Institute for Radiation Protection and Nuclear Safety IRSN (Institut de Radioprotection et de Sûreté Nucléaire, a French public authority) calculated in several studies the costs, which **France** would have to face in case of a severe or very severe nuclear accident. On its website IRSN published the study which makes estimates on two accidents of differing severity in a French NPP (IRSN 2012). IRSN listed the following areas, which are relevant for the overall costs:

1. Those costs contain all clean-up costs at the NPP site like decontamination and decommissioning of the plant, but also replacement capacity the electricity, which the plant cannot produce any more.

2. Off-site costs for radiological matters: IRSN includes the costs for emergency measures (e.g. evacuation), health costs, costs for the psychological treatment including the costs for days of sick leave and losses in agricultural production.

3. Image costs: They include consequences like crisis in sales of „clean" products due to a lack of consumer confidence (in particular French wine was mentioned), reduced tourism, reduced export rates.

4. Energy generation costs: This is where assumptions are made, how an accident would impact the future of the nuclear plant fleet in France, e.g. a reduction of reactor operation times.

5. Costs due to contaminated areas (exclusion zones and other areas): These are the costs for people who had to be re-settled and the costs for the zones themselves.

6. Additional follow-up costs like impacts on the national debt level, the stock prices, foreign investments etc. could also occur. The calculations however were not designed to take those into account.

As a beginning a severe accident (INES Level 6[43]) was assumed, based on a meltdown, which however can be controlled more or less. The accident was called "representative"; probably supposed to mean that for the source term and weather conditions no extreme values were assumed. The number of people in need of re-settlement was given as 3,500. The authors mentioned a range of -55% to +100% for a "better" or "worse" case.

[43] The IAEA INES Scale (International Nuclear Event Scale) has 7 levels, level 7 being a Major Accident. From Level 4 onwards it is not an „incident" anymore, but an „accident", at level 6 radioactivity is being released to a grave extent also outside the facility.

The following tables show the assessed costs for different accident scenarios:

Table 7: Costs of representative accident in France INES 6 (IRSN 2012)

	Billion euro	Billion US$[44]	Percentage
On-Site Costs	6	8	5%
Off-site Costs	9	13	8%
Image Costs	47	63	40%
Costs of Energy Generation	44	58	37%
Costs due to contaminated areas	11	16	10%
Total Costs	**120**	**158**	**100%**
Range of Total Costs	**50-240**	**66-320**	

For a catastrophic accident (INES Level 7) as it has taken place in Chernobyl or Fukushima, the following costs are estimated. Around 100,000 people are assumed to be in need for re-settlement.

Table 8: Costs of a Large Representative Accident in France INES 7 (IRSN 2012)

	Billion euro	Billion US$[45]	Percentage
On-Site Costs	8	11	2%
Off-site Costs	53	68	12%
Image Costs	166	221	39%
Costs of Energy Generation	90	119	21%
Costs due to contaminated areas	110	147	26%
Total Costs	**427**	**566**	**100%**
Range of Total Costs	**172-946**	**226-1.242**	

Here, too, the authors offer a range of -60% to +120% of the result. At the upper limit of the range they assume that massive contamination might have affected large urban areas.

After the study was presented to the public in February 2013 and received major media responses, a second IRSN study came to light which had presumably been written in 2007. The French newspaper *Le Journal de Dimanche* published an article on this second study on March 10, 2013.[46] The author of this second study is

[44] Exchange rate of 17 April 2013

[45] Exchange rate of 17 April 2013

[46] http://www.lejdd.fr/Economie/Actualite/Exclusif-JDD-le-scenario-noir-du-nucleaire-595593, accessed 17 April 2013

the same as in the study presented above: Patrick Momal. The 2007 study, which, however, is not accessible, is based on much more catastrophic scenarios. It estimates that 5 million people will have to be evacuated from an area of 87,000 km^2 (for comparison: Austria´s has a territory of 83,855 km^2). 90 million people would be living in an area of 850,000 km^2 contaminated with Cesium-137 (no further details provided on the level of contamination). The scenario uses a weather situation which would result in consequences for Paris. The overall costs which would be incurred reach to **€ 760-5,800 billion (US$ 998-7,615 billion).** The current French budget is € 2,000 billion (US$ 2,600 billion), the follow-up costs would be almost three-fold.

6.2 CONCLUSIONS

Several different studies have calculated the costs of a major Beyond Design Basis Accident in the range of ***US$* 71 and *5,800 billion.*** This wide range shows how difficult it is to assess the actual costs of such an accident. What does appear certain is that a catastrophic ***accident generates costs*** in the range of ***100's if not 1000's of billions***.

The following factors pose limitations on the considered accidents: 1) the published figures on the Chernobyl accident are questionable because the period following the accident at Chernobyl was impacted by the economic and political break-down in the former Soviet Republic, plus a policy of secrecy and the wish to cover-up the consequences. 2) The Fukushima accident was relatively recent, making it impossible to estimate the costs in necessary detail. 3) The French studies showed how different accident scenarios can have a huge impact on the costs. The worst case scenario in the IRSN studies, which obviously includes a massive contamination of Paris, is very interesting. According to the online tool flexRISK[47], some scenarios show that radioactive emissions from the NPP Dampierre are transferred to Paris. The assumed costs of up to US$ 5,800 billion for this type of accident would by far exceed the several hundred billion US$ reported as the follow-up costs for Chernobyl.

The scenarios used for calculating the consequences of accidents contain a large number of parameters which have an impact on the result. It makes an enormous difference if the complete inventory or only a fraction of the radioactive inventory is released, whether the release lasts hours, days or weeks, and how the weather situation contributes to blowing away or raining down the radioactive particles. The regions impacted can vary greatly in terms of population density and socio-economic structure.

The next logical thought is that someone has to pay for such an accident. Therefore the funds available to cover nuclear liability should be checked to see to what extent they can cover a maximum damage. The low probability of such an accident is not a sufficient argument because, as we saw in Chernobyl and Fukushima, such accidents do occur. The next part of this chapter will examine the question of liability.

[47] http://flexrisk.boku.ac.at

6.3 LIABILITY FOR NUCLEAR ACCIDENTS

Since the 1960s, international agreements have been in place to regulate the question of nuclear liability. The insurance industry has encouraged these regimes in order to achieve better regulation for damages of international dimensions (Schärf 2008). The liability was to be geared towards the operator/owner of a nuclear facility, which provides relief for the suppliers and therefore as a certain level of security for the nuclear industry. Damage to persons, loss of property and financial losses need to be compensated for (Kerschner/Leidenmühler 2012).

All those conventions have in common the definition of damage for which liability is provided, the regulation of who compensates damages, that liability applies also without fault and which courts are competent (Greenpeace 2013, WNA 2013).

In 1960, and mainly for the OECD countries, the first agreement, the ***Paris Convention on Nuclear Third Party Liability,*** was concluded***.*** The Paris Convention was supplemented in 1963 by the ***Brussels Supplementary Convention*** which was updated in 1982. The ***Protocol to Amend the Brussels Convention Supplementary of 2004*** is not yet in force. According to the Paris Convention, a Paris Convention member state is not liable for an accident which takes place on the territory of a non-convention state, however, other agreements can be made at national level. The Brussels Supplementary Protocol ensures that additional compensation is made from national and international funds, where compensation from the Paris Compensation is insufficient (Schärf 2008).

The ***Vienna Convention on Civil Liability for Nuclear Damage*** was agreed in 1963, revised in 1997, and is open to all states. The ***Protocol to Amend the 1963 Vienna Convention on Civil Liability for Nuclear Damage*** raised the liability limits in 1997.

The ***Protocol Relating to the Application of the Vienna Convention and the Paris Convention - Joint Protocol*** linked these two conventions (agreed in 1988 and entered into force in 1992).

Another agreement, the ***Convention on Supplementary Compensation*** of 1997 is not yet in force.

Important nuclear states such as the US, Canada, China, India, Japan etc. have not signed any of these agreements. Overall, liability for half of the world's nuclear power plant fleet is not subject to the regulation of one of the conventions (WNA 2013). Many states, however, have their own regulations for dealing with questions of liability, whether they have ratified one of the Conventions or not.

6.4 JOINT PROJECT COUNTRIES: WHICH COSTS ARE COVERED

6.4.1 BULGARIA

Bulgaria is a signatory of the *Vienna Convention*, which entered into force in 1994.

According to Art. 132, al. 1 of the Law on the Safe Use of Nuclear Energy (LSUNE), the operator's liability for any nuclear damage is capped to 96 million BGN (**49.084 million EUR**). Since 2002, Kozloduy NPP has been contracting an insurance companies pool on a year-to-year basis for the mentioned amount.

This sum is meant for potential compensations inside and outside Bulgaria.

It is obvious that 49 million EUR would cover only a small proportion of the costs a country would face in case of a severe accident. One of the reasons for such a small sum we see in the legislative provision that any compensations should be claimed in the court. It is unclear in this situation whether and how the Government would act proactively towards civil population during an accident.

A short calculation shows that in case of 100,000 heavily affected citizens, the per capita compensation would be about 490 EUR on average – which is definitely not enough - neither for medical treatment nor for material compensation of contaminated property.

Text by Genady Kondarev, Za Zemiata

6.4.2 CZECH REPUBLIC

Liability

The Czech Republic ratified the Vienna Convention on Civil Liability for Nuclear Damage in September 1994 and signed the Protocol amending the Vienna Convention, which tightens up the states' responsibility for nuclear damage.

An amendment of the Atomic Law is currently under preparation - the Atomic Law in the new wording will be probably passed in 2014. Among other things, the Atomic Law deals with issues of nuclear facility operators' liability for damage caused by a potential accident; this liability is limited to CZK 8 billion **(€ 306.2 million**) in the Czech Republic.

However, such an amount would not, by a long shot, cover the damages incurred by a serious accident.

Unfortunately, the Atomic Law amendment in preparation maintains the operators' limited liability of CZK 8 billion. In addition, it "transfers" the limited liability issue into a so-called "residual" act of law so that one of the major disputed issues is handled separately in the amending procedure so as not to complicate the passing of the new Atomic Act.

As for compensations for entities abroad affected and afflicted by a nuclear accident, the SONS has only informed us generally that the compensations would be made in accordance with Article XIII of the 1963

Vienna Convention saying "This Convention and the national law applicable thereunder shall be applied without any discrimination based upon nationality, domicile or residence." No further details were given.

Text by Monika Wittingerova, South Bohemian Mothers

6.4.3 HUNGARY

Liability

Hungary joined the Vienna Convention at the 28 July 1989, which entered into force 28 October 1989. Hungary has not yet ratified the Vienna Convention; its status is „accession". Hungary has also joined to the Joint Protocol, on the 20 September 1989. The status of Hungary is „approval"; the Joint Protocol entered into force at 27 April 1992.

The amount of liability in Hungary for nuclear installations is **100 million SDR for each nuclear accident**. In the case of transporting or storing nuclear fuel the amount of liability is 5 million SDR. Losses above these limits are reimbursed by the state, up to 300 million SDR altogether[48] (see table below).

Table 9: Nuclear liability in Hungary

Liability of the users of nuclear energy (million)[49]			
	SDR	EUR	HUF
Nuclear installation	100	111.51	35008.86
Transport, storage	5	5.58	1750.44
Additional liability of the state (million)			
	SDR	EUR	HUF
Nuclear installation	200	223.02	70017.71
Transport, storage	295	328.97	103276.13

Concerning the compensation of damages in foreign countries, the 60. Article of the Act CXVI of 1996 stipulates that the same rules like in the case of the damages in Hungary should be applied, if Hungary is bound to do so by international agreement. Rules of the law could be applied without the existence of such international agreement.

Text by András Perger, Energia Klub

[48] According to the Act CXVI of 1996

[49] For the exchanges: http://hu.coinmill.com, 18th March 2014

6.4.4 POLAND

With respect to the nuclear accidents liability, Poland is a party to the:

- Convention of Vienna on Civil Liability for Nuclear Damage concerning nuclear liability of 21 May, 1963 which it ratified on 8 December, 1989 (date of entry into force: 23 April, 1990);
- Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention (on liability for nuclear damage), done at Vienna on 21 September, 1988 which it ratified on 27 April, 1992 (it entered into force on the same day);
- Protocol to Amend the 1963 Vienna Convention on Civil Liability for Nuclear Damage of 12 September 1997 done at Vienna which it ratified on 14 May, 2010 (date of entry into force: 21 December, 2010).

The liability for the operator of an NPP is limited to **300 Mill SDR** (equivalent in PLN) for one nuclear 'event' (article 102.1 of the Polish Atomic Law). This is also the amount of a related financial security (article 103.6 of the Polish Atomic Law).

The financial security of an insurance against a nuclear event for a research reactor or transport of material derived from it is limited by the power of the article 102.1 of the Polish Atomic Law within the range of 400,000 and 5,000,000 SDR (equivalent in PLN). This minimal amount is defined by an ordinance of the Ministry of Finance and Ministry of Economy of 2011 at 400,000 SDR.

The priority rules on compensation for nuclear damage are established under Articles 103c and 105 of the Polish Atomic Law. If the nuclear accident results also in personal injury, 10% of the financial security is to be earmarked for the settlement of claims involving such a class of nuclear damage. This is enforceable for a period of at least 5 years. After expiry of this period this amount can as well be used for settlement of claims relating to property damage, economic loss or environmental damage. If the corresponding financial security is not available or is insufficient to satisfy all nuclear damage claims, the Polish National Treasury shall guarantee the payment of up to the limit of 300,000,000 SDR. In that case the operator shall set up a, so called, 'fund _for_ a limited liability'. For procedures related to expenditures from this fund, adequate rules of the 'Sea Act on limited liability for sea claims' [ref: Kodeks morski o ograniczeniu odpowiedzialności za roszczenia morskie] are, to a large extent, applicable. Claims for the compensation of personal injury shall not be barred by limitations in time.

Regulations concerning compensation of injured persons living outside the territory of Poland are governed by the article 160.3 of the Polish Atomic Law which only refers the claims to be settled to the appropriateness of courts defined by the Vienna Convention.

Text by Marcin Harembski

6.4.5 ROMANIA

Liability

Romania is a signatory of the Vienna Convention, which was ratified in 1992. According to the VC, the liability amount for a signatory country is 300 million SDR (~ 338 Mio. €, special drawing rights). Therefore, the operator's liability is limited in Romania to 300 million SDR, according to national legislation. An important mention in the national law is that the operator, with the special approval of the regulating authority, could be liable to pay less than **300 million SDR, but no less than 150 million SDR**. The difference in this case has to be allocated by the state from public funding.

If a nuclear accident, which affects persons from neighbouring countries, should happen the operator of the Romanian state is only liable to compensate those that are not already compensated through an international convention regarding civil liability for nuclear damage.

Text by Lavinia Andrei and Mihai Stoica, Terra Mileniul III

6.4.6 CONCLUSION 1: UNDERINSURANCE

What is the amount of liability each NPP operator has to make available in each Joint Project country, and what funds need to be covered by other sources?

The following table provides an excerpt of the different liability limits for nuclear power plants in Europe (NEA 2011) and information of the Joint Project NGOs:

Table 10: Limits of nuclear liability in the Joint Project countries

Country	Operator´s Liability	Additional Compensation Provided by the State	Additional Compensation Provided by International Agreements
Bulgaria	~ € 49.1 Million (BGN 96 Million)	-	-
Czech Republic	~ € 306.2 Million (CZK 8 billion)	-	-
Hungary	~ € 109 Million (SDR 100 Million)	~ € 217.9 Million (SDR 200 Million)	-
Poland	~ € 327 Million (SDR 300 Million)		
Romania	~ € 163.5 Million (SDR 150 Million)	~ € 163.5 Million (SDR 150 Million)	-

To sum up: the valid amounts for nuclear liability are way too low. A very conservative estimate of the Fukushima costs have already shown that at least US$ 71 billion in costs can be expected, however, this sum is likely to be much higher. Compared to the worst case data issued by IRSN for France, of over US$ 7,000 billion, the existing liability amounts are ridiculously low. The question arises - who is going to pay the difference?

Even where we assume nuclear liability coverage of US$ 450 million (an amount most states do not guarantee) – then compared to the accident costs outlined earlier, the following levels of coverage would result:

Table 11: Costs of Accidents Covered by the Nuclear Liability

		Costs of Accident	Assumption of liability	Coverage
Chernobyl, only Costs in Belorussia acc. to Chernobyl Forum (2006)		$ 235,000,000,000	$ 450,000,000	**0.19%**
Fukushima acc. to JCER (2011a)	from	$ 71,000,000,000	$ 450,000,000	**0.63%**
	to	$ 250,000,000,000	$ 450,000,000	**0.18%**
Fukushima acc. to JCER (2011b)	from	$ 520,000,000,000	$ 450,000,000	**0.09%**
	to	$ 650,000,000,000	$ 450,000,000	**0.07%**
France acc. to IRSN (2012)	from	$ 226,000,000,000	$ 450,000,000	**0.20%**
	to	$ 1,242,000,000,000	$ 450,000,000	**0.04%**
France (Scénario noir)	from	$ 460,000,000,000	$ 450,000,000	**0.10%**
	to	$ 5,800,000,000,000	$ 450,000,000	**0.008%**

For all the assumed cases, coverage is less than – in some cases way under – 1 %. In addition, unclear situations arise when it comes to asserting claims for compensation, in particular if affecting a state which is not party to any of the above convention.

Moreover, legally speaking the nuclear states are walking on thin ice: as Kerschner and Leidenmühler note in their 2012 study, operators of non-nuclear power plants in Europe do not have a maximum liability limit. They regard the limited liability for nuclear power plants as set out in the international conventions as a violation of the ***Polluter Pays Principle.***

The limited liability and the states' assumption of liability lead to savings on insurance premiums for the NPP operators. This constitutes ***preferential treatment by the state*** for which the NPP operator does not deliver a sufficient service in return.

6.4.7 CONCLUSION 2: IMPACT OF FULL INSURANCE ON THE ELECTRICITY PRICE

The *Versicherungsforen Leipzig* insurance forum (Gunther et al. 2011) conducted a comprehensive study into the issue of a sufficient financial coverage of nuclear accidents.

The authors arrived at the following conclusions:

*"If the costs for clean-up caused by such an occurrence of damage would have to be paid by the consumers of nuclear generated power (internalization of external effects), by spreading the costs of the insurance premium based on it over the availability period of 100 years, then the consequence would be an increase in the price of nuclear generated power (net value) for the period of **100 years** in the range of **€ 0.139 per***

kWh up to € 2.36 per kWh. *For a period of availability of* ***10 years,*** *the range would be* ***€ 3.96 per kWh up to € 67.3 per kWh****."*

"Looking at the overview of kWh costs for the individual scenarios it becomes clear that, with regards to the situation in Germany, there is ***no possibility of fully covering the risk*** *resulting from the operation of NPP.* ***Only with an accumulation phase of 100 years*** *of a surcharge on the electricity price will a pool covering all NPP risk reach an order of magnitude which at first glance seems payable. In light of the residual lifetimes of German NPPs, and normal lifetimes of 25 to 40 years,* ***much shorter accumulation phases would have to be realized to guarantee the availability of the funds before the risk ceases to exist because of nuclear phase-out.*** However, ***no realistic financing method*** exists for this scenario. At the same time this underlines the problem of the immediately risk which is present when starting operations, and before sufficient funds are available to compensate for damages occurring when the risk materializes."

This is summarized by following conclusions:

- Even if nuclear industry would be granted the period of ***100 years*** to accumulate the funds needed in case of a possible nuclear accident, the consumer would have to pay ***extra costs*** of ***0.139 – 2.36 €/kWh.***

  > For comparison: Current power generation costs are around 0.018 – 0.079 €/kWh (1.8 – 7.9 €-Cent/kWh) (Thomas et al. 2007, p. 35): Over 100 years the power generation costs than would increase to 0.157 – 2.439 €/kWh– i.e. by ***3 to 50-fold***[50]***!***

> It is practically impossible to finance full insurance for a nuclear accident during the lifetime of a NPP: If appropriate funds are to be made available over a period of ***10 years***, the additional costs would amount to at ***3.96 – 67.3 €/kWh***.
>
> In turn, the impact on power generation costs would be to increase them, to 4.1 – 67.4 €/kWh, i.e. by ***80 – 1,300-fold!***

In both scenarios nuclear power becomes completely uneconomically.

[50] referring to average power generation costs of 0.05 €/kWh

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8 USEFUL LINKS

Links about the Joint Project

Joint Project Webpage –

http://www.joint-project.org

Links to Joint Project members

Za Zemiata (BG) - http://www.zazemiata.org
Calla (CZ) - http://www.calla.cz
South Bohemian Mothers (CZ) - http://www.jihoceskematky.cz/en/
Energy Club (HU) - http://www.energiaklub.hu/en/
Common Earth (Wspólna Ziemia) (PL) - http://www.wspolnaziemia.org/?lg=&a=7
Terra Mileniul III (RO)- www.terramileniultrei.ro
Hungarian Environmental Partnership Foundation (HEPF) - http://okotars.hu/en
Austrian Institute of Ecology (AT) - http://www.ecology.at