The Real Cost of Electricity Production

Bilateral Paper

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Abstract

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1. Introduction

2. Externalities

First of all, you have to understand externalities and environmental valuation methods in theory, before you can work with them empirically. In this chapter the reader should get an overview how equilibrium is built in a competitive market, the problem of externalities and what is environmental valuation.

The following information is substantially taken out of the books 'Mikroökonomik' (Pindyck, Rubinfeld, 2009), 'Auf welche Art und Weise beeinflussen Institutionen die ökonomische Effizienz?' (Wößner, 2004), Wealth and Welfare (Pigou, 1912) 'Theorie der Wirtschaftspolitik 4. Auflage' (Streit 1991).

To explain how the equilibrium on a competitive market comes about makes sense, because the European Electricity Market is liberalized. The liberalized European Electricity Market should change the market from a monopoly to a competitive market. On a Competitive Market you can find the equilibrium by combine the supply and demand curves. The demand curve has a negative slope for normal goods. This results out of Gossen's demand curve of decreasing marginal utility. In the opposite of the demand curve, the supply curve has a positive slope, which is plausible because at lower prizes the demand is lower than at higher prizes.

As it is assumed that market participants[1] act utility maximizing and rational, economic efficiency will be able when there is full information and no agent is large enough to have market power. This efficient allocation could be disturbed by economic policy. That is not true at all, because market failure is quite common.

Market failure is possible, if the market participants do not have full information or there exist public goods or externalities. Externalities result out of economical activities and could be shown as additional utilities or costs, which are not included in the market prize. This means, that the causal

1 Market participants are those individuals in a society that can have a positive or negative influence on the development of an economy. For example companies as well as private and public households.

agent has no incentive to compensate anyone for the additional cost or gets no compensation for the additional utility caused by her behaviour. In the chapter Negative External Effects and Positive External Effects external effects will be explained more detailed. The reader can find the topic environmental valuation in chapter Environmental Valuation.

2.1. Negative External Effects

Negative external effects last to additional cost for third person and are besides the public good problem the second socioeconomic reason for market failure. Aggrieved agents have no impact on the additional cost because the market participants act non cooperative (Farmer, Stadler, 2005, S.124). Negative external Effects are called external Costs. You can see them at environmental and health damages or the costs which are caused by global warming (Krewitt, Schlomann, 2006, S. 5). External costs emerge especially in the sectors of energy economy and traffic system.

We distinguish internal (private) and external costs, which constitute the social costs. Since the amount produced depends on marginal costs, the marginal social cost should be taken to achieve an economical efficient allocation on the market. Negative external effects lead to higher prices and lower produced quantities, if you give respect to them and internalize them (Pindyck, Rubinfeld, 2009, S. 838).

2.2. Positive External Effects

A positive external effect causes additional utilities for third person without any additional costs to get them (Farmer, Stadler, 2005, S.124). That is the reason, why positive external Effects are also called external utilities or social profit (Pindyck, Rubinfeld, 2009, S. 839).

In the opposite to negative external effects, the produced quantity of the good which lasts to positive external effects is to low. The production gives no respect to the additional marginal utility. If positive external effects are included into the market price, the prizes should fall and therefore the produced quantities increase till you reach an economical efficient allocation.

2.3. Environmental Valuation

If someone wants to internalize external costs to get an economical efficient allocation on the market, you need to quantify and monetize those additional costs. There are direct, indirect and methodical valuation models which are elucidated in the following captors.

2.3.1.Indirect Valuation Methods

You can divide indirect valuation methods up into the travel cost method (TCM) and the hedonic pricing method (HPM). Indirect valuation methods try to estimate the value of the environment by using data, which are correlated to the environmental good. The demand behaviour should be derived from the value of the environment.

2.3.1.1. Travel Cost Method

This model was evolved to estimate the value of the environment out of the private cost for the journey to use the environment good. The aggregated travel costs are taken to create a demand function, from which you can estimate the value of the environment. This method was quite often used in the USA to estimate the monetized value of national parks (Perman et al., 2003, p. 411). At the TCM all private costs of the journey must be correlated to the good, from which the value is to be elicited (Schwermer, Weiß, 2007, p. 66). There are three possibilities to accomplish the TCM. The first version, which is analytically analyzed in this paper, is called zonal TCM. You can get the relevant data for this version from survey data and combine them with secondary data. The second version is the individual TCM and the third version is the random-utility-approach (Schwermer, Weiß, 2007, p. 91).

The following analysis is made by information from 'Natural Resource and Environmental Economics (Perman et. al, 2003, p. 211-420)' and 'The value of conservation? A literature Review of the Economic and social Value of the cultural Built Heritage.' (Allison, 2000, p.12).

First of all at the TCM you have to elicit the private cost for the journey. You can get the data out of a survey or a Marshall-Consumer-Surplus-Zonal model. Secondly the amount of visitations and the travel costs are aggregated and get multiplied with the amount of visits per year. A demand function could be constructed from that, where the willingness to pay can be derived from fictitious prizes of entry.

1)

is the visit-generating-function. It shows how often an individual i visits the environmental good with respect to C and X_N. C are the cost of a visit from origin i or by individual i. X_N are other relevant variables. It is assumed that the travel costs show the value of the environment and that C comprises the travel cost T as well as the admission price P. That is the reason why V increases while C decreases and vice versa.

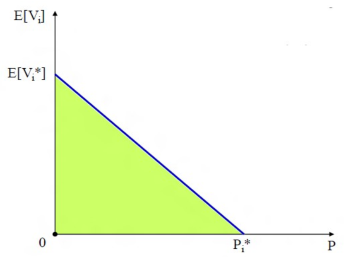
2)

The second function results, if it is assumed that the function f is linear in costs and suppresses the variables X_N. is an error term which is neglected. For a value of zero is assumed. is negative. That results out of the coherence from V and C which was explained in 1). are derived from the variables Vi and Ti and should help to built the demand function.

3)

E[ ] is an expectation operator. It shows how an individual visits the environmental good expectably. To get the maximal value of the environment, you have to set the prize P zero as you can see at Figure . With a positive prize, the consumer surplus would decrease and therefore the value of the environment.

4)



e, if you rearrange 3). After you maximize 3) and 4) you can derive nalezen.

Figure the linear trip generating function

5)

As it was mentioned in 3), the prize of the environment is set zero to get the maximal value. The green Area in Chyba: zdroj odkazu nenalezen shows the consumer surplus and could be calculated with 5) the Marshallian consumer surplus. The consumer surplus could be shown better, if you modify the linear trip-generating function by including different zones. If there are different zones, the value of the environment could be precisely estimated.

There are some problems with the travel cost method. First of all at the step from 1) to 2) it was estimated that the function is linear in costs. But the coherence could also be nonlinear and therefore shown as the following function. In general that formula is taken, which fits better with the empirical data (Perman et. al, 2003, p. 415). Furthermore from formula 1) to 2) it was assumed that other relevant variables like X_N are suppressed. That is a strong assumption and the result could be therefore wrong (Perman et. al, 2003, p. 415). Such a relevant suppressed variable could be the income of the individual, which is quite often crucial for the amount of visits.

More Problems result out of the subjective grading of the travel costs. The travel costs should be determined by the traveller itself (Randall, 1994, p. 93). The costs of the journey could vary in a broad band between the individuals due to different factors. On the one hand individuals can see the time of travelling as opportunity costs and on the other hand it could be perceived as an amenity (Perman et. al, 2003, p. 416-417).

Another point of criticism accrues out of the lack of consideration substitute goods and preferences into the model. Due to that, the result will be distorted (Parowicz, 2006, p. 56).

As the environment is more used when its quality is good, there are problems later. Some residents have chosen their permanent facilities because of the convenience of the good quality of the environment but they are excluded from the TCM (Bahadir et. al, 2000, p. 981).

Summarizing we can say, that the TCM is a useful method to evaluate the environment, because it uses real data from real decisions and behaviour pattern. TCM could be used to measure changes in the value of the environment due to external effects, which result from anthropogenic activities. A sensitivity analysis should be made, because there are some problems with the TCM.

2.3.1.2. Hedonic Pricing

The hedonic pricing method is another alternative indirect environmental valuation method. It uses data from goods whose value is correlated to the quality of the surrounding environment (Schwermer, Weiß, 2007, p. 89). This Method tries to estimate the value of the environment by a replacement market (Rosen, 1974, p. 34) and is quite often used with problems due to air and water pollution, toxic waste and other environmental problems (Perman et. al, 2011, p. 445-446). Although air is not traded on the market, there is a positive correlation between the rents of an apartment and the air quality in that area (Perman et. al, 2003, p. 435), because an environment which is in a good order increases the convenience and therefore the prices for housing prizes (Faucheux, Noël, 2001, p. 331). Important data for the HPM could be the housing rents, house prices, air quality, and a set of attributes which influence the housing rents (Opaluch et. al, 1999, p. 12, p. 14). These influencing factors could have a positive impact on the housing prices as well as a negative one.

The HPM starts with the technique of multiple regressions to measure the effects on the housing prices. After that it uses a regression analysis to find out the different reactions due to some factors which last to different prices. The different prices could be used to derivate the willingness to pay of the agents (Faucheux, Noël, 2001, p. 332).

It is important, that the influencing factors are clearly separated. If they correlate the results of the HPM would be unstable. A quick adjustment of the prices to a change of the environment quality is assumed. Therefore regulated housing rents could disturb the result of the analysis (Schwermer, Weiß, 2007, p. 90).

Summarizing we can say, that the HPM is a good instrument to measure the quality of the environment, because it works with real data. That is also the reason, why this method is efficient in cost and time.

1.1.1. Direct Valuation Method

Direct environmental valuating methods could be used to estimate each external cost. They also could be used to compensate the weak points of the indirect valuation methods. These methods are very useful to valuate the impact of an external effect on the human health (Schwermer, Weiß, 2007, p. 81). Compared to the indirect methods, the purchase of the data is very complex and therefore time consuming and costly. That is the reason why they should be used, according to the theory, just if indirect methods are not possible. But direct valuation methods are the best way to estimate the value of the environment. The contingent valuation and its different varieties are the most famous direct methods (Faucheux, Noël, 2001, p. 330).

1.1.1.1. Contingent Valuation

The contingent valuation method (CVM) could be used to calculate the willingness to pay (WTP) as well as the willingness to accept (WTA) by using data from a survey (Perman et. al, 2011, p. 415). The name results because this valuation method is dependent on hypothetical sceneries (Perman et. al, 2003, p. 420). Since the 1970's it is the most used environmental valuation method (Hanley et. al, 2007, p. 332) and is widely used to measure impacts from projects and political decisions on the air and water quality (Perman et al, 2011 p. 415). As we mentioned before there are different varieties of the CV method. The easiest way of making a CVM is that the survey asks directly for how much the respondent would pay for a change in the environment due to a project or political decision. More complicated CVM's try to find out the value which the respondents would accept to pay to prevent the environment from a change (Tietenberg, 2006, p. 38- S.39). The most advanced version of CVM takes place in several steps.

At *Step 1* the survey instrument for the elicitation of the WTP or WTA is chosen. The interviewer can decide between three sceneries: 1) a direct interview to get the WTA or WTP, 2) a hypothetical scenario, 3) derivate the means of payment by eliciting the willingness of side payments (Perman et. al, 2003, p. 421). If the survey is chosen, it will be used in *step 2*. The survey could be done by a personal interview, E-Mail or a interview via telephone. First of all the interviewer should inform the respondent about the hypothetical scenario. After that the survey starts. It consists out of several categories of questions. One of them tries to find out the knowledge of about the environment. Another category tries to find out the WTA or WTP. Some control questions try to figure out if the answers are set strategically or not. Also information about the socioeconomic and demographic data are gathered by the survey (Hanley et al., 2007, p. 333).

Step 3 tries to evaluate the WTP or WTA. First of all the interviewer has to decide if she takes the mean or median to estimate the WTA or WTP for the whole society (Perman et al. 2003, p. 425). It is important that the relevant population is asked. Out of them the average WTA or WTP is taken to extrapolate it up for the whole population. It is important that the respondents have somehow the same characteristics, otherwise the survey makes no sense (Perman et al. 2011, p. 419-420). To evaluate the answers socioeconomic and demographic data are elicited too, as we mentioned in step 2. By means of these data the calculated WTA or WTP out of Step 3 are evaluated in *Step 4*. *Step 5* is used for sensitivity analysis and validity checks (Hantley et al., 2007, p. 337).

The results of the CVM strongly depend on the way how the questions are asked. This causes different bias (Faucheux, Noël, 2001, p. 343). Some bias result out of the different availability of information of the respondents. But there are also strategic, hypothetic, conceptual biases (Tietenberg, 2006, p. 39).

The CVM is often criticised because it uses hypothetical scenarios and questions in the opposite to the indirect environment valuation methods. But the CVM has substantial advantages over indirect methods. First the CVM can deal with use and non use values, while indirect methods just involve weak complementary assumptions (Perman et. al, 2003, p. 420). Second the CVM gives respect to the income effect because it uses the hicksian demand unlike the indirect methods use the marshalian demand (Faucheux, Noël, 2001, p. 330). Third the CVM can directly include the WTA or WTP into the theoretically correct monetary measure of utility change (Perman et. al, 2003, p. 420). As the CVM is very sophisticated and time consuming, it is not possible to use it neither for each project and political decisions nor every external effect (Schwermer, Weiß, 2007, p. 17)

Summarizing we can say, that the CVM is a useful and reliable instrument to evaluate the impact of projects and political decisions on the environment. As they are sophisticated, time consuming and cost intensive, it is not recommended to use them to measure the impacts of small projects on the environment and all external effects.

1.2. Integrated Assessment Model

Integrated Assessment Models (IAM) are used to estimate the costs of the climate change and its consequential damages (Krewitt, Schlomann, 2006, p. 11). IAM combine scientific knowledge and the impact of economical activities. It is an interdisciplinary process where various scientific disciplines, with their typical methods to try to reach a common solution, which should provide useful information for policy decisions (Rotmans, Dowlatabadi, 1997).

One of the most famous and developed IAM is the 'ExternE' (Krewitt, Schlomann, 2006, p. 9). Since it was evolved in 1991, there has been much progress in the in the analysis by over 50 research teams in more than 20 countries. The ExternE IAM tries to measure all impacts of the external effects on the economy, ecology, sociology and environment (ExternE, 2010). The methodology of the ExternE has several steps and basic principles.

The examining activities, the most important impacts and impact categories as well as externalities are defined at *stage 1*. At the second stage, *stage 2*, the impacts of the external effects going to be measured. This impact can be measured by the change in the results of the scenario by include the project or policy or exclude them. The instruments as we mentioned in chapter Chyba: zdroj odkazu nenalezen are used in *stage 3* to monetize the impacts. Sensitivity analysis and the assessment of the uncertainties are carried out in *stage 4*. In the final stage, *stage 5*, the results are evaluated and the interviewer can make conclusions out of it.

The principles of the ExternE are shown here:

Principle 1: the most important impacts are going to be defined. The ExternE uses only quantitative figures and procedures because this ensures transparent and reproducible results.

Principle 2: everything is transformed into monetary units because that leads to some advantages. The first one is that monetary units are transferable from one application to another. Secondly you can compare costs to benefits (if the benefits are converted into monetary units too). And the third advantage is, that politicians know how to set the taxes or other instruments to internalise the external effects.

Principle 3: Preferences of the affected population is the basis for the assessment of the impacts of the external effects.

Principle 4: The interviewed person needs to be informed. Only if the answerers are informed, a meaningful result is possible.

Principle 5: A detailed bottom-up calculation is able to appreciate site, time and technology dependence. To measure the environmental impacts, an impact pathway approach is used

Principle 6: The aggregated external costs depend on the nature of the question.

These steps and principles should show that the environmental valuation methods we mentioned in chapter are used in the empiricism. The empirical appliance is now shown in chapter ExterneE project2. As there are a lot of environmental valuation methods, the German Umwelt Bundesamt had made a guideline for the method choice, which is examined in chapter Guidelines for the method selection.

1.3. Guidelines for the method selection

The results of the assessment methods only can be used for environmental measures, if the values are accepted for environmental goods. Therefore, the German Umwelt Bundesamt für Mensch und Umwelt has carried out a guideline for the selection of the environmental valuation methods to monetize the external costs (Schwermer, White, 2007, p. 66-67).

As environmental valuation models quantify just a small amount of the external costs, only lower limits of the value of the environment are set out. First of all it should be checked if marked pricing methods are useful in the case of external effects because on the one hand they are cost and time efficient and on the other hand they are easier to understand. HPM should be only applied if there is a clear link between housing prices and the prevailing environment. At the TCM the private costs for the journey must be absolutely correlated to the environmental good. Otherwise the WTP or WTA is not the correct one. As we mentioned in chapter Direct Valuation Method direct methods could be combined with indirect methods to annul some problems and evaluate the external costs of all external effects and cost and benefit categories.

External effects that causes on the one hand health risks and on the other hand damages due to climate change are the most important external effects in the power generation sector. Approximately 95 % of all external effects result from air pollutants and green house gases in this sector. In chapter ExterneE project2 the valuation of the external costs is empirically calculated with the IAM which we mentioned in chapter Integrated Assessment Model.

2. ExterneE project[2]

Calculations from ExternE project in response to environmental doses are done by a complex computer method and by „back of the envelope"calculation. Those methods calculate monetary value of damages which are caused by releases into the rivers, seas, air and soil. Rest of the damages are calculated in response to accidents caused by transportations.

2.1. Mining and milling

In ExternE project assumes, that the installation has about 30 year's functional lifetime. In this case, total costs connected with mining and milling are 0,0645 mECU/kWh (0,0016 CZK/kWh) with no discount rate, 0,0184 mECU/kWh (0,0005 CZK/kWh) with 3% discount rate and 0,0063 mECU/kWh (0,0002 CZK/kWh) with 10% discount rate.

What is really important in this section of generating electricity is occupational impact (almost about 50%). Remaining 50% are attributed due to air and atmospheric releases. In fact, air and atmospheric releases are in very small doses, which can experience only individuals in area with 1 000 km radius. Impact of uranium and his isotopes are almost zero.

Monetary valuation of mining and miling in mECU/kWh. In 0%, 3% and 10% discount rate

mECU/kWh	Short term			Medium term			Long Term			Sub-total	Sub-total in Euro	Sub-total in CZK
	Local	Regional	Global	Local	Regional	Global	Local	Regional	Global			
0%	0,0148	0,0000	0,0000	0,0323	0,0169	0,0000	0,0003	0,0002	0,0000	0,0645	0,0001	0,0016
3%	0,0099	0,0000	0,0000	0,0056	0,0029	0,0000	0,0000	0,0000	0,0000	0,0184	0,0000	0,0005
10%	0,0052	0,0000	0,0000	0,0007	0,0004	0,0000	0,0000	0,0000	0,0000	0,0063	0,0000	0,0002

2.2. Conversion

In this case, total costs of conversion are 0,001 mECU/kWh (2,41E-05 CZK/kWh) with no discount rate, 0,0005 mECU/kWh (1,18E-05 CZK/kWh) with 3% discount rate and 0,0002 mECU/kWh (5,59 CZK/kWh) with 10% discount rate. Conversion redound less than 1% of the total cost, which were calculated for fuel cycle. Rest of them (99%) contribute to occupational impacts. All in all, these damages are non-radiological nature, caused in the facilities.

Monetary valuation of conversion in mECU/kWh. In 0%, 3% and 10% discount rate

mECU/kWh	Short term			Medium term			Long Term			Sub-total	Sub-total in Euro	Sub-total in CZK
	Local	Regional	Global	Local	Regional	Global	Local	Regional	Global			
0%	0,0006	0,0000	0,0000	0,0003	0,0000	0,0000	0,0000	0,0000	0,0000	0,0010	0,0000	2,4116E-005
3%	0,0004	0,0000	0,0000	0,0001	0,0000	0,0000	0,0000	0,0000	0,0000	0,0005	0,0000	1,1790E-005
10%	0,0002	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0002	0,0000	5,5889E-006

2.3. Enrichment

In this case, total cost from enrichment are 0,0012 mECU/kWh (2,95E-05 CZK/kWh) with no discount rate, 0,0008 mECU/kWh (1,95E-05 CZK/kWh) with 3% discount rate and 0,0004 mECU/kWh (1,02E-05 CZK/kWh) with 10% discount rate.

More than 99% of the total costs are caused by occupational impacts. These damages are caused mostly by non-radiological accidents that appears in the facilities. Environmental costs are much more lower than occupational costs. Inhalation, liquid release and agricultural ingestion are much lower than external exposure. Liquid releases impacts are approximately 300 times lower than from atmospheric releases.

2 EXTERNE. Externalities of Energy: *Vol. 5: Nuclear*. Luxembourg: ECSC-EC-EAEC, 1995. ISBN 92-827-5214-3.

Monetary valuation of enrichment in mECU/kWh. In 0%, 3% and 10% discount rate

mECU/kWh	Short term			Medium term			Long Term			Sub-total	Sub-total in Euro	Sub-total in CZK
	Local	Regional	Global	Local	Regional	Global	Local	Regional	Global			
0%	0,0012	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0012	0,0000	2,9464E-005
3%	0,0008	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0008	0,0000	0,000019501
10%	0,0004	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0004	0,0000	1,0192E-005

2.4. Fuel Fabrication

In ExternE project calculated, that total costs form fuel fabrication are approximately 0,0019 mECU/kWh (4,68E-05 CZK/kWh) with no discount rate, 0,007 mECU/kWh (1,81E-05 CZK/kWh) with 3% discount rate and 0,003 mECU/kWh (7,66E-06 CZK/kWh) with 10% discount rate.

This stage of the fuel cycle, do not take an important part of the total fuel cycle. The occupational impacts constitute 99% of the cost of fuel fabrication stage. These damages are mostly caused by radiological impacts. Cost from liquid damages is two times bigger than from inhalation and external exposures.

Monetary valuation of fuel fabrication in mECU/kWh. In 0%, 3% and 10% discount rate

mECU/kWh	Short term			Medium term			Long Term			Sub-total	Sub-total in Euro	Sub-total in CZK
	Local	Regional	Global	Local	Regional	Global	Local	Regional	Global			
0%	0,0008	0,0000	0,0000	0,0011	0,0000	0,0000	0,0000	0,0000	0,0000	0,0019	0,0000	4,6796E-005
3%	0,0005	0,0000	0,0000	0,0002	0,0000	0,0000	0,0000	0,0000	0,0000	0,0007	0,0000	1,8119E-005
10%	0,0003	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0003	0,0000	7,6578E-006

2.5. Electricity generation

Total cost from electricity generation takes almost 0,4667 mECU/kWh (0,0115 CZK/kWh) with no discount rate, 0,0599 mECU/kWh (0,0014 CZK/kWh) with 3% discount rate and 0,0403 mECU/kWh (0,0009 CZK/kWh) with 10% discount rate.

In this case dominate (in 83% share) global public impacts. It's necessary to know, that this collective dose is combined by doses by 10 billion peoples in 100 000 years. If the global impact are not included, occupational cost adds 94% of the total costs.

Monetary valuation of electricity generation in mECU/kWh. In 0%, 3% and 10% discount rate

mECU/kWh	Short term			Medium term			Long Term			Sub-total	Sub-total in eurocents	Sub-total in CZK
	Local	Regional	Global	Local	Regional	Global	Local	Regional	Global			
Electricity Generation PWR 900												
0% Con.	0,0337	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0337	0,0000	0,0008
0% Op.	0,0131	0,0000	0,0000	0,0528	0,0032	0,0277	0,0000	0,0000	0,3190	0,4160	0,0004	0,0103
0% Dec.	0,0000	0,0000	0,0000	0,0170	0,0000	0,0000	0,0000	0,0000	0,0000	0,0170	0,0000	0,0004
3% Con.	0,0337	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0337	0,0000	0,0008
3% Op.	0,0088	0,0000	0,0000	0,0092	0,0004	0,0018	0,0000	0,0000	0,0001	0,0203	0,0000	0,0005
3% Dec.	0,0000	0,0000	0,0000	0,0060	0,0000	0,0000	0,0000	0,0000	0,0000	0,0060	0,0000	0,0001
10% Con.	0,0337	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0337	0,0000	0,0008
10% Op.	0,0046	0,0000	0,0000	0,0012	0,0000	0,0001	0,0000	0,0000	0,0000	0,0059	0,0000	0,0001
10% Dec.	0,0000	0,0000	0,0000	0,0008	0,0000	0,0000	0,0000	0,0000	0,0000	0,0008	0,0000	0,0000

2.6. Reprocessing

In this case, tolal cost are 1,92 mECU/kWh (0,0475 CZK/kWh) with no discount rate, 0,0145 mECU/kWh (0,0004 CZK/kWh) with 3% discount rate and 0,0019 mECU/kWh (4,70E-05 CZK/kWh) with 10% discount rate.

To understand a large number, which is noticed in this section, it's good to know, that in the present, value of the water grows up. Due to the hudge polutions which came into the water, quality of fishes felt down. This indirectly harms health of individuals a lot. That is the reason, why monetary value of reprocessing costs is too high.

Monetary valuation of reprocessing in mECU/kWh. In 0%, 3% and 10% discount rate

mECU/kWh	Short term			Medium term			Long Term			Sub-total	Sub-total in Euro	Sub-total in CZK
	Local	Regional	Global	Local	Regional	Global	Local	Regional	Global			
0%	0,0030	0,0000	0,0000	0,0003	0,0096	0,1600	0,0000	0,0017	1,7400	1,9200	0,0019	0,0475
3%	0,0020	0,0000	0,0000	0,0001	0,0013	0,0106	0,0000	0,0000	0,0006	0,0145	0,0000	0,0004
10%	0,0010	0,0000	0,0000	0,0000	0,0001	0,0007	0,0000	0,0000	0,0001	0,0019	0,0000	0,0000

2.7. Low and intermediate level radioactive waste disposal

Low level radioactive waste disposal cost approximately 0,0048 mECU/kWh (0,0001 CZK/kWh) with no discount rate, 0,00001 mECU/kWh (2,12E-07 CZK/kWh) with 3% discount rate and 4,13 mECU/kWh (1,02 CZK/kWh) with 10% discount rate.

Monetary valuation of LLW dispsal in mECU/kWh. In 0%, 3% and 10% discount rate

mECU/kWh	Short term			Medium term			Long Term			Sub-total	Sub-total in Euro	Sub-total in CZK
	Local	Regional	Global	Local	Regional	Global	Local	Regional	Global			
0%	-	0,0000	0,0000	0,0000	0,0000	0,0001	0,0000	0,0000	0,0047	0,0048	0,0000	0,000118848
3%	-	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,00001	0,0000	2,1024E-007
10%	-	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	4,1259E-007	0,0000	1,0181E-008

2.8. High level radioactive waste disposal

High level radioactive waste disposal, on the other hand, cost 0,0254 mECU/kWh (0,0006 CZK/kWh) with no discount rate, 6,41E-09 mECU/kWh (1,58E-10 CZK/kWh) with 3% discount rate and 1,12E-10 mECU/kWh (1,76E-12 CZK/kWh) with 10% discount rate.

This dose has monetary valuation about 1% of the total external cost, which ExternE project Calculated. This is very insignificant message. If 3% or 10% discount rate is used, level of waste disposal has no influence on the total external costs.

Monetary valuation of HLW disposal in mECU/kWh. In 0%, 3% and 10% discount rate

mECU/kWh	Short term			Medium term			Long Term			Sub-total	Sub-total in Euro	Sub-total in CZK
	Local	Regional	Global	Local	Regional	Global	Local	Regional	Global			
0%	-	0,0000	0,0000	0,0000	0,0000	0,0000	0,0254	0,0000	0,0000	0,0254	0,0000	0,0006
3%	-	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	6,41E-009	0,0000	1,5817E-010
10%	-	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	1,12E-010	0,0000	2,7637E-012

2.9. Transportation

In this case, total cost of transpiration are 0,0008 mECU/kWh (0,00002 CZK/kWh) with no discount rate, 0,0003 mECU/kWh (7,68E-06 CZK/kWh) with 3% discount rate and 0,0001 mECU/kWh (3,46E-06 CZK/kWh) with 10% discount rate.

The main share in high of 54% is represent by public exposure, which is emitted mostly along the routes. Rest of this percent are formed by physical impacts connected with the accidents (mostly deaths and injuries). All in all this section is the smallest of the total external cost of all fuel cycle.

Monetary valuation of transportation in mECU/kWh. In 0%, 3% and 10% discount rate

mECU/kWh	Short term			Medium term			Long Term			Sub-total	Sub-total in Euro	Sub-total in CZK
	Local	Regional	Global	Local	Regional	Global	Local	Regional	Global			
0%	0,0004	0,0000	0,0000	0,0004	0,0000	0,0000	0,0000	0,0000	0,0000	0,0008	0,0000	0,000019288
3%	0,0002	0,0000	0,0000	0,0001	0,0000	0,0000	0,0000	0,0000	0,0000	0,0003	0,0000	7,6792E-006
10%	0,0001	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0001	0,0000	3,4591E-006

2.10. Summary of results

The main goal of ExternE project wo to show monetary damages, which rises from the releases of nuclear fuel cycle. Those damages are caused mostly by occupation on public health and from radiological and non-radiological sources. In some cases even by accidents on the roads.

In this project must be said, that total costs, are only subtotal. It's impossible to involve all the cost into the calculation. The sub-total costs of nuclear fuel cycle is almost 0,1 mECU/kWh if we use 3% discount rate. The rest projections (with 0% and 10% discount rate), have range from 0,05 to 2,49 mECU/kWh.

2.10.1. Summary of 0% discount rate scenario

In this scenario, which has not so much interpretive value[3], real cost which should be included into the cost of the ČEZ[4], are 69 435 040 EUR. This is the costs, which are not included into the fuel cycle, but they should be. In fact, influence on the consumer is be minimal. Less than 6 EUR have to pay consumer per year, if these 69,5 mil. EUR will be included into the price.

Table 2.10.1

Monetary valuation in mECU/kWh with no discount rate.

mECU/kWh	Short term			Medium term			Long Term			Sub-total	Sub-total in Euro	Sub-total in CZK
	Local	Regional	Global	Local	Regional	Global	Local	Regional	Global			
Mining and Milling	0,0148	0,0000	0,0000	0,0323	0,0169	0,0000	0,0003	0,0002	0,0000	0,0645	0,0001	0,0016
Conversion	0,0006	0,0000	0,0000	0,0003	0,0000	0,0000	0,0000	0,0000	0,0000	0,0010	0,0000	0,0000
Enrichment	0,0012	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0012	0,0000	0,0000
Fuel Fabrication	0,0008	0,0000	0,0000	0,0011	0,0000	0,0000	0,0000	0,0000	0,0000	0,0019	0,0000	0,0000
Electricity Generation PWR 900												
- Construction	0,0337	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0337	0,0000	0,0008
- Operation	0,0131	0,0000	0,0000	0,0528	0,0032	0,0277	0,0000	0,0000	0,3190	0,4160	0,0004	0,0103
- Decommissioning	0,0000	0,0000	0,0000	0,0170	0,0000	0,0000	0,0000	0,0000	0,0000	0,0170	0,0000	0,0004
Reprocessing	0,0030	0,0000	0,0000	0,0003	0,0096	0,1600	0,0000	0,0017	1,7400	1,9200	0,0019	0,0475
LLW Disposal	-	0,0000	0,0000	0,0000	0,0000	0,0001	0,0000	0,0000	0,0047	0,0048	0,0000	0,0001
HLW Disposal	-	0,0000	0,0000	0,0000	0,0000	0,0000	0,0254	0,0000	0,0000	0,0254	0,0000	0,0006
Transportation	0,0004	0,0000	0,0000	0,0004	0,0000	0,0000	0,0000	0,0000	0,0000	0,0008	0,0000	0,0000
Sub-Total	0,0675	0,0000	0,0000	0,1040	0,0297	0,1880	0,0257	0,0019	2,0600	2,4800	0,0025	0,0614

Table 2.10.2[5]

Calculation of Total External Costs with no discount rate

Electricity production (in Gwh)	27 998
Additional external cost per kWh	0,06119648
Total External Costs (in EUR)	69 435 040
Total External Costs (in CZK)	1 713 379 047

3 Because of 0% discount rate, which is not almost apper in the real world.

4 Sole owner of the nuclear power stations in Czech Republic.

5 ČEZ, a. s. *Výroční zpráva 2010*: *Skupina ČEZ*. Praha: ČEZ, a. s., 2011, 306 s.

Table 2.10.3[6]

Calculation of price of 1kWh of electricity paid by consumer

Tarif D02d	before the increase	after the increase
Price per kWh in EUR	0,196	0,198
Price per kWh in CZK	4,830	4,891
Yearly consumption in kWh	2 200,000	2 200,000
Yearly consumption in EUR	430,621	436,077
Yearly consumption in CZK	10 626,000	10 760,632
Yearly payment for cirquit breaker in EUR	72,945	72,945
Yearly payment for cirquit breaker in CZK	1 800,000	1 800,000
Total payment in EUR	503,566	509,022
Total payment in CZK	12 426,000	12 560,632

2.10.2. Summary of 3% discount rate scenario

In this scenario, which has the biggest interpretive value, real cost which should be included into the cost of the ČEZ, are 2 662 816 EUR. This is the costs, which are not included into the fuel cycle, but they should be. Influence on the consumer is less than in the scenario before. Less than 0,2 EUR have to pay consumer per year, if these 2,7 mil. EUR will be included into the price of electricity.

Table 2.10.4

Monetary valuation in mECU/kWh with 3% discount rate.

mECU/kWh	Short term			Medium term			Long Term			Sub-total	Sub-total in eurocents	Sub-total in CZK
	Local	Regional	Global	Local	Regional	Global	Local	Regional	Global			
Mining and Milling	0,0099	0,0000	0,0000	0,0056	0,0029	0,0000	0,0000	0,0000	0,0000	0,0184	0,0000	0,0005
Conversion	0,0004	0,0000	0,0000	0,0001	0,0000	0,0000	0,0000	0,0000	0,0000	0,0005	0,0000	0,0000
Enrichment	0,0008	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0008	0,0000	0,0000
Fuel Fabrication	0,0005	0,0000	0,0000	0,0002	0,0000	0,0000	0,0000	0,0000	0,0000	0,0007	0,0000	0,0000
Electricity Generation PWR 900												
- Construction	0,0337	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0337	0,0000	0,0008
- Operation	0,0088	0,0000	0,0000	0,0092	0,0004	0,0018	0,0000	0,0000	0,0001	0,0203	0,0000	0,0005
- Decommissioning	0,0000	0,0000	0,0000	0,0060	0,0000	0,0000	0,0000	0,0000	0,0000	0,0060	0,0000	0,0001
Reprocessing	0,0020	0,0000	0,0000	0,0001	0,0013	0,0106	0,0000	0,0000	0,0006	0,0145	0,0000	0,0004
LLW Disposal	-	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
HLW Disposal	-	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Transportation	0,0002	0,0000	0,0000	0,0001	0,0000	0,0000	0,0000	0,0000	0,0000	0,0003	0,0000	0,0000
Sub-Total	0,0564	0,0000	0,0000	0,0211	0,0046	0,0124	0,0000	0,0000	0,0007	0,0951	0,0001	0,0023

Table 2.10.5[7]

Calculation of Total External Costs with 3% discount rate

Electricity production (in Gwh)	27 998
Additional external cost per kWh	0,0023468691
Total External Costs (in EUR)	2 662 816
Total External Costs (in CZK)	65 707 640

6 CENY ENERGIE. *Ceny elektřiny 2012* [online]. 2012 [cit. 2012-04-24]. Available at: http://www.cenyenergie.cz/nejnovejsi-clanky/ceny-elektriny-2012-cez-a-pre-zdrazi-e-on-zlevni.aspx

7 ČEZ, a. s. *Výroční zpráva 2010*: *Skupina ČEZ*. Praha: ČEZ, a. s., 2011, 306 s.

Table 2.10.6[8]

Calculation of price of 1kWh of electricity paid by consumer

Tarif D02d	before the increase	after the increase
Price per kWh in EUR	0,196	0,196
Price per kWh in CZK	4,830	4,832
Yearly consumption in kWh	2 200,000	2 200,000
Yearly consumption in EUR	430,621	430,830
Yearly consumption in CZK	10 626,000	10 631,163
Yearly payment for cirquit breaker in EUR	72,945	72,945
Yearly payment for cirquit breaker in CZK	1 800,000	1 800,000
Total payment in EUR	503,566	503,775
Total payment in CZK	12 426,000	12 431,163

2.10.3. Summary of 10% discount rate scenario

This is the scenario, where the real costs, which should be included into the cost of the ČEZ, have almost zero influence. In this situation ČEZ have to include into the cost only 1 376 522 EUR. This not included costs have even smaller effect that in the scenario before. Consumer have to pay 0,1 EUR per year, if these 1,4 mil. EUR will be included into the price of electricity.

Table 2.10.7

Monetary valuation in mECU/kWh with 10% discount rate.

mECU/kWh	Short term			Medium term			Long Term			Sub-total	Sub-total in eurocents	Sub-total in CZK
	Local	Regional	Global	Local	Regional	Global	Local	Regional	Global			
Mining and Milling	0,0052	0,0000	0,0000	0,0007	0,0004	0,0000	0,0000	0,0000	0,0000	0,0063	0,0000	0,0002
Conversion	0,0002	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0002	0,0000	0,0000
Enrichment	0,0004	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0004	0,0000	0,0000
Fuel Fabrication	0,0003	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0003	0,0000	0,0000
Electricity Generation PWR 900												
- Construction	0,0337	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0337	0,0000	0,0008
- Operation	0,0046	0,0000	0,0000	0,0012	0,0000	0,0001	0,0000	0,0000	0,0000	0,0059	0,0000	0,0001
- Decommissioning	0,0000	0,0000	0,0000	0,0008	0,0000	0,0000	0,0000	0,0000	0,0000	0,0008	0,0000	0,0000
Reprocessing	0,0010	0,0000	0,0000	0,0000	0,0001	0,0007	0,0000	0,0000	0,0001	0,0019	0,0000	0,0000
LLW Disposal	-	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
HLW Disposal	-	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Transportation	0,0001	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0001	0,0000	0,0000
Sub-Total	0,0456	0,0000	0,0000	0,0027	0,0000	0,0008	0,0000	0,0000	0,0001	0,0492	0,0000	0,0012

Table 2.10.8[9]

Calculation of Total External Costs with 10% discount rate

Electricity production (in Gwh)	27 998
Additional external cost per kWh	0,0012132236
Total External Costs (in EUR)	1 376 553
Total External Costs (in CZK)	33 967 833

8 CENY ENERGIE. *Ceny elektřiny 2012* [online]. 2012 [cit. 2012-04-24]. Available at: http://www.cenyenergie.cz/nejnovejsi-clanky/ceny-elektriny-2012-cez-a-pre-zdrazi-e-on-zlevni.aspx

9 ČEZ, a. s. *Výroční zpráva 2010*: *Skupina ČEZ*. Praha: ČEZ, a. s., 2011, 306 s.

Table 2.10.9[10]

Calculation of price of 1kWh of electricity paid by consumer

Tarif D02d	before the increase	after the increase
Price per kWh in EUR	0,196	0,196
Price per kWh in CZK	4,830	4,831
Yearly consumption in kWh	2 200,000	2 200,000
Yearly consumption in EUR	430,621	430,729
Yearly consumption in CZK	10 626,000	10 628,669
Yearly payment for cirquit breaker in EUR	72,945	72,945
Yearly payment for cirquit breaker in CZK	1 800,000	1 800,000
Total payment in EUR	503,566	503,674
Total payment in CZK	12 426,000	12 428,669

10 CENY ENERGIE. *Ceny elektřiny 2012* [online]. 2012 [cit. 2012-04-24]. Available at: http://www.cenyenergie.cz/nejnovejsi-clanky/ceny-elektriny-2012-cez-a-pre-zdrazi-e-on-zlevni.aspx

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