Economy of Power Supply Options for Latvia

Issue paper from INFORSE-Europe[1] and Latvian Green Movement (LGM)
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Background

This paper discusses expected costs of possible new heat and power supply for Latvia with renewable energy and conventional fuels. It also includes nuclear power, not because there are any plans for nuclear power in Latvia but because the country is considering to take part in the investment of a nuclear power plant in Lithuania.

INFORSE-Europe and LGM has developed a sustainable energy vision with a transition of the Latvian energy supply to efficient use of renewable energy as well as a description of the actions needed to realise the first part of the vision until 2020.

With this paper the costs of the electricity and heat supply options proposed for the sustainable energy vision is compared with less sustainable options. The comparison is done with similar conditions and with expected future fuel costs.

Expected Fuel Prices

Fossil fuel prices have fluctuated widely during 2008, and seems to be on a slow increasing trend in the beginning of 2009. For this evaluation is used current prices as well as future prices as forecasted by IEA[2] in its World Energy Outlook 2008: 100-120 US$/barrel of oil (lower value until 2015 then increasing to higher value)and 120 US$/ ton of coal (2010-2015). Opposite to World Energy Outlook there is not included a reduction of coal process after 2015, as the rational for such a decrease is questionable. For gas prices is used a current (2008) price of 350 USD/1000 m3 and for the future the oil price minus 30%, indicating an increasing decoupling between gas and oil prices. Since gas in Latvia is coming exclusively from Russia, the actual future gas price will depend on bilateral negotiations.

For biomass prices is used Latvian wood chip prices from mid-2008 of 7 Lat/m3 of solid wood equivalent. This price is now lower because of the economic prices, but it can be expected to increase again with the increased market for biomass. The future wood prices are of course also dependant on future markets, but as it is produced inside Latvia, the costs are more dependant on costs of land and labour than on international energy markets. The cost of wood from energy plantations can estimated to 10 €/MWh excluding land-use costs and there is a large potential for energy plantations on currently unused land in Latvia.

For straw is used a low price of 25% of the wood-chip price as straw is not used today and the price therefore reflect its status as a waste product. Of course the amount of straw that can be delivered as such a low price will have clear limits linked to grain production and need for straw for animals etc.

This gives the following fuel prices for current and future situations, with a €/US$ rate of 1,25:

	Oil		Coal		Gas		Wood chips		Straw	
	€/GJ	€/MWh	€/GJ	€/MWh	€/GJ	€/MWh	€/GJ	€/MWh	€/GJ	€/MWh
Present	7,9	28,4	2,2	8,0	7,1	25,5	3,5	12,5	0,9	3,1
Future	15,8	56,8	4,4	16	11,0	39,7	3,5	12,5	0,9	3,1

Table 1: Present and expected future fuel prices for Latvia

1 International Network for Sustainable Energy - Europe, a network of 70 European NGOs working for energy efficiency and renewable energy, see www.inforse.org/europe
2 International Energy Agency, Paris

Heat Production with Solid Biomass

The production of heat with solid biomass is the easiest way of using biomass for energy, but as it only cover one part of energy demands, it is also limited. It is used throughout the world. For this overview is given costs of boilers of 2 MW and up working with wood-chips. Below 2 MW there is an economy of scale (so larger boilers produce cheaper heat); but from about 2 MW the economy of scale is limited.

In below example is used a 50 MW boiler house. Investments are total investments to turn-key plants, here and in the following examples.

Parameter	Unit	heat
Specific investment costs	mill. € / MW-th	**0,32**
Capacity installed	MW-th	**50**
Total investment	mill. €	16
Lifetime	years	**20**
LFCC	€/MWth	27779
O&M-1	€/MWth/year	**19118**
O&M-2	€/MWh	**0**
Eq.full load	hours/year	**5500**
O&M costs	mill €/year	1,0
Eff-total	%	**105**
Fuel costs	€/MWh	12,5
Heat costs	€/MWh heat	20
Heat costs	LAT/MWh	14

Table 2: Data and heat costs from wood-chip heating in Latvia, costs of input to district heating. Bold figures are input data from below sources. Figures with normal font are calculated from input data.

Investment costs and lifetimes are from "“Technology Data for Electricity and Heat Generating Plants”, report published by the Danish Energy Authority et.al. March 2005, ISBN: 87-7844-503-5, data for solid biomass (wood chip) fired boiler house. Costs are added 27% to reflect inflation from 2002 (the base-year for the report) to 2008. Straw-fired plants are about 20% more expensive.

LFCC = Levelised Fixed cost charge is the annual payment to cover investment costs spread equally over the lifetime and with 6% interest rate on investment.

O&M (operating and maintenance costs, divided in fixed and variable) are from above-mentioned “Technology Data for Electricity and Heat Generating Plants” and added 27% for inflation.

Equivalent full-load hours are set to 5500 hours for all plants to give an equal basis for comparison.

Efficiency is based on realised efficiencies in Scandinavia with flue gas condensation.

This cost is lower than the consumer price of district heating that will also include network losses, network investment and maintenance, operation and administration.

Combined Power & Heat (CHP) Production With Solid Biomass

Solid biomass in the form of wood chips is widely used for power production in the Scandinavian countries. Straw is also used, but to less extent. The technology is basically the same steam cycle turbines as used in coal power plants, with few modifications. Often larger plants are made for different fuels and co-firing of different fuels including biomass, coal, gas and heavy fuel oil. Biomass power plants need less sulphur scrubbers than plants for coal, but NOx cleaning demands is similar.

With modifications plants can be used for different solid fuels. There is a large economy of scale, so large power plants are both cheaper per MW installed than smaller plants and have larger electric efficiencies.

Four types of plants are used in the sustainable energy vision for Latvia. The reference plants are all steam-cycle plants where steam is produced in a boiler. and electricity is produced in a steam turbine. The four types are:

- large CHP plants mainly for wood chips, 400 MW electric power, electric efficiency of 46,5% and total efficiency of 90%. In Latvia the heat from such large plants can only be used fully in Riga. As references are two existing plant: the Avedoere 2 plant in Denmark (and the Alholmen 2 plant in Finland.
- medium CHP plants, 80 MW electric power for wood chips, 40% electric efficiency, and 90% total efficiency. In Latvia this plant-size is useful for medium-sized towns such as Daugaupils (120 MW), Liepaja (90 MW), Ventspils (40 MW). There are several reference plants in Scandinavia countries, such as plants in Södertälje, Sweden (85 MW); Lund, Sweden (50 MWe); Enköbing, Sweden (24 MWe); ; Porvoo, Finland (30-40 MWe).
- smaller CHP plants for wood chips, 10 MW in size, for smaller towns and larger industries, steam cycle plants. There are many reference plants in Scandinavia, Germany, and Austria.
- smaller CHP plants for straw, 10 MW in size, for smaller towns and larger industries. There are a few existing reference plants, including Sakskøbing, Denmark

To evaluate these power plant, we use following plant characteristics and cost estimates:

Parameter	Unit	Bio-CHP-large	Wood-CHP-small	Wood-CHP-medium	Straw-CHP-small
Specific invest. Costs	mill. € / Mwe	**1,66**	**3,19**	**2,8**	**5,1**
Capacity installed	Mwe	**400**	**10**	**80**	**10**
Total investment	mill. €	663	32	224	51
Lifetime	years	**30**	**20**	**30**	**20**
LFCC	€/Mwe	120369	231479	203702	444470
O&M-1	€/Mwe/year	**31863**	**89216**	**79020**	**259900**
O&M-2	€/MWh	**3**	**19**	**16**	**0**
Eq.full load	hours/year	**5500**	**5500**	**5500**	**5500**
O&M costs	mill €/year	20	1,9	13	2,6
Eff-el	%	**44**	**34**	**40**	**30**
Eff-total	%	**90**	**95**	**90**	**91**

Table 3 Data for solid biomass power plants

Bold figures are input data from below sources. Figures with normal font are calculated from input data.

Investment costs and lifetimes are from "“Technology Data for Electricity and Heat Generating Plants”, report published by the Danish Energy Authority et.al. March 2005, ISBN: 87-7844-503-5, data for solid biomass fired power plant of 400 MW, wood-fired and straw-fired plants of 10 MW. Costs are added 27% to reflect inflation from 2002 (the base-year for the report) to 2008. Investment costs for medium-sized plants are interpollations.

LFCC = Levelised Fixed cost charge is the annual payment to cover investment costs spread equally over the lifetime and with 6% interest rate on investment.

O&M (operating and maintenance costs, divided in fixed and variable) are from above-mentioned “Technology Data for Electricity and Heat Generating Plants” and added 27% for inflation.

Equivalent full-load hours are set to 5500 hours for all plants to give an equal basis for comparison.

Electric efficiencies are based on realised plants 1999 - 2003 and “Technology Data for Electricity and Heat Generating Plants”. For large CHP-plants the realised efficiency is 42% and the report estimates for future plants 46.5%, so in this study is used 44%. For small CHP plants realised efficiencies are 30% and the report estimates future efficiencies of 38% so in this study is used 34%. For small, straw-fired power plants the realised efficiency is 28% and the report estimates 30% for future plants, so in this study is used 30%. For medium-sized plants is used logarithmic interpolation between small and large to estimate the efficiency of 40%

Total efficiency are also based on realised plants and “Technology Data for Electricity and Heat Generating Plants”. For large CHP plants realised efficiency is 92% which is used. For small CHP plants are used realised efficiency of 95% for wood-fired and the reports data of 92% for straw-fired plants. For medium-sized plants are used 92% as for large plants.

If heat is sold for the cost of producing heat from wood-chip heating plants, which often will be the alternative, the electricity production costs can be calculated to the following values:

Power costs in €/MWh	Bio-CHP-large	Wood-CHP-small	Wood-CHP-medium	Straw-CHP-small
Investment	14	29	28	57
O&M	6	24	23	33
Fuel costs	18	25	23	7
Total	39	78	74	97

Table 4 Electricity costs from solid fuel power plants with heat selling costs of 20 €/MWh

The costs are calculated as the total costs of producing 1 MWh of electricity and subtracting the income from the amount of heat generated in co-production. The split between investements, O&M and fuel costs is proportional to the split of costs for the entire production with heat included.

Windpower and Biogas Plants

Some renewable energy production have no fuel costs. This includes windpower, solar energy, geothermal energy and also biomass plants where the fuel is free such as the sludge used for biogas. For Latvia we are including windpower and biogas plants as the most relevant solutions for large-scale power production within the coming 10 years. For windpower is chosen a land based site with 2000 full load hours equivalent to a capacity factor of 23%, a value that is achieveable in many sites in the more windy parts of Latvia (Western part if the country). The calculation is made for a wind park of 100 MW, but the price difference for other sizes of developments are small.

For biogas is chosen a large plant with a 3 MW gas motor. This will be a plant for several farms. Plants for individual farms tend to be relatively expensive per produced, but have lower handling costs of the manure as the manure does not have to be moved between the farms and the plant. For the biogas plant is made two calculations: one with 5500 operating hours similar to the other biomass plants and one with 7500 MW, assuming the heat can be utilised all year round and that the plant is just closed for 1.5 month during summer for maintenance etc.

		Windpower	Biogas	Biogas
Specific investment costs	mill. € / Mwe	**1**	**3,82**	**3,82**
Capacity installed	MWe	**100**	**3**	**3**
Total investment	mill. €	100	11	11
Lifetime	years	**20**	**20**	**20**
LFCC	€/Mwe	87185	333353	333353
O&M-1	€/Mwe/year	**0**	**0**	**0**
O&M-2	€/MWh	**10**	**33**	**33**
Eq.full load	hours/year	**2000**	**5500**	**7500**
O&M costs	mill €/year	2	0,5	0,7
Eff-el	%	n.a	35	35
Eff-total	%	n.a	55	55

Table 5 Data for windpower and biogas power (CHP) plants
Bold figures are input data from below sources. Figures with normal font are calculated from inout data.

For windpower the input data are taken from INFORSE-Europe's work in a European "Windforce10". Due to the large development of windpower, costs have kept stable in current prices for almost a decade.

For biogas plants input data are from “Technology Data for Electricity and Heat Generating Plants” with costs addded 27% for inflation. The low total efficiency of 55% is because a part of the heat generated is consumed in the process to heat the digester tank(s).

If heat is sold for the cost of producing heat from wood-chip heating plants, which often will be the alternative, the electricity production costs can be calculated to the following values:

Power costs, €/MWh	Windpower	Biogas 5500 hours/year	Biogas, 7500 hours/year
Investment	44	53	38
O&M	10	29	28
Total	54	82	66

Table 6 Electricity costs from windpower and from biogas plants with heat selling costs of 20 €/MWh

Fossil and Nuclear Power Plants

To compare the renewable energy option, we include costs of gas, coal and nuclear power plants are also included. The plants represen generally state-of-the-art technology. For gas-fired plants are included an 80 MW CHP plant with an electric efficiency of 44% and a 200 MW combined-cycle

CHP plant with an electric efficiency of 60%. For coal-fired plants are included a 400 MW CHP plant with an electric efficiency of 45% and a 400 MW power-only plant with an efficiency of 52%. It can be questioned if the power-only plant is state-of-the-art, but as such a plant has been proposed for Latvia, it is relevant to include it. The following data are used for these power plants:

		News gas CHP	New Gas CC-CHP	New coal CHP	New Coal, el-only	Nuclear
Specific investment costs	mill. € / MWe	0,64	0,7	1,53	1,53	5,24
Capacity installed	MWe	80	200	400	400	1000
Total investment	mill. €	51	140	612	612	5240
Lifetime	years	25	30	30	30	50
LFCC	€/MWe	49850	50925	111110	111110	332448
O&M-1	€/MWe/year	9304	15931	20392	20392	174000
O&M-2	€/MWh	3	2	2	2	7
Eq.full load	hours/year	5500	5500	5500	5500	5500
O&M costs	mill €/year	2,1	5,3	13	13	213
Eff-el	%	44	60	45	52	n.a.
Eff-total	%	92	90	93	52	n.a.

Table 7 Data used for fossil and nuclear power plants

Costs, lifetimes, and efficiencies for fossil fuel power plants is from “Technology Data for Electricity and Heat Generating Plants”, increased with 27% because of inflation.

For nuclear power plants costs and lifetimes are from "Moody’s Corporate Finance (May 2008), ‘New Nuclear Generating Capacity’" which is one of the latest independent analysis of nuclear power plants. An economic lifetime of 50 years is optimistic and it might be worthwhile to include a calculation with a lifetime of 40 years.

For all power plants are included 5500 full load hours to set all options on an equal level. For all options the economy will improve with a higher capacity, but there is only a limited demand for year-round base-load and to put all options equal, this value is chosen. It might be worthwhile to include calculations with 7500 full load hours.

To calculate costs of fossil and nuclear power plants fuel costs are important. Fossil fuel costs are quite different today from expected future costs as can be seen in table 1. Therefore calculations are made with both present and future expected fuel costs.

For nuclear power fuel costs are due to severe dispute as they must also include proper management of mining and of waste, both of which are often neglected or only included partially. Also the uranium cost itself is fluctuating with a peak in 2007, lower present prices and expected higher prices with the depletion of uranium stocks from the cold war. Using a uranium price of 100 USD/pound of U_3O_8, and estimates of waste management costs, the fuel cost all included is 16 €/MWh. Of course this does not include unexpected problems with the nuclear power plants, decommissioning, or waste-management.

This gives the following electricity costs from new fossil and nuclear power:

Power costs in €/MWh, present prices	News gas CHP	New Gas CC-CHP	New coal CHP	New Coal, el-only	Nuclear*
Investment	6	8	11	20	60
O&M	3	4	3	6	39
Fuel costs	40	35	9	15	16
Carbon costs	5	4	7	10	
Total	55	51	30	51	115

Power costs in €/MWh, future prices	News gas CHP	New Gas CC-CHP	New coal CHP	New Coal, el-only	Nuclear*
Investment	7	8	14	20	60
O&M	4	4	4	6	39
Fuel costs	71	58	'(26)	'(33)	16
Carbon costs	9	8	15	20	
Total	91	78	58	79	115

Table 8 Costs of fossil and nuclear power plant option with present and future prices of fuels. For fossil fuel-fired plants is included a carbon cost of 15 €/ton for present prices and 30 US€/ton for future prices.

Variations

If the economic lifetime of the nuclear power plant is reduced from 50 years to 40 years, it will increase nuclear power costs with 3 €/MWh to 118 €/MWh.

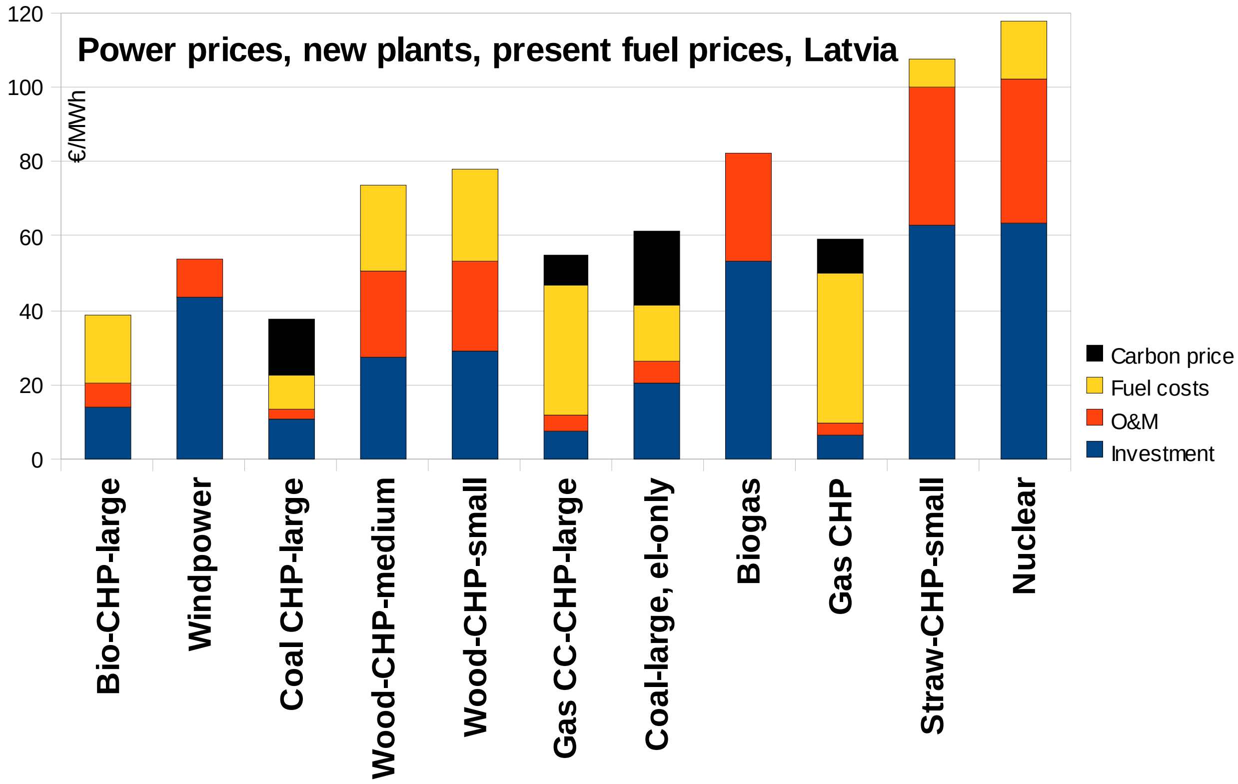
If the operating hours are increased from 5500 hours/year to 7500 hours/year, it will decrese production costs per MWh substantially for the different plants. For CHP plants, increased operating hours can result in waste of heat for a part of the year, which is similar to a lower average heat selling price, if all heat is wasted in the additional 2000 hours from 5500 hours/year to 7500 hours/year, the average heat selling price is reduced from 20 €/MWh to 15 €/MWh (only 3/4 of the heat is sold). Results are shown for selected power plant options in the table below (nuclear power plants with 50 year lifetime as in the geenral calculations):

		Bio-CHP-large	Wood-CHP medium	Straw-CHP small	Bio-gas	New Gas CC-CHP	New Coal, el-only	Nuclear
Costs @ 5500 h/y	€/MWh	39	74	97	82	78	79	118
Costs @ 7500 h/y all heat is sold	€/MWh	31	60	63	66	75	73	93
Costs @ 7500 h/y 3/4 of heat is sold	€/MWh	36	66	73	69	78	73	93

Table 9 Costs of power production at full load hours of 5500 and 7500 hours/year.

The table shows that with larger production period, the economy of the "free-fuel" biogas plant is improved substantially while the smallest effect is seen for the gas-fired power plant in the table.

Comparing the Options
The power plant options are compared for present and future energy costs.



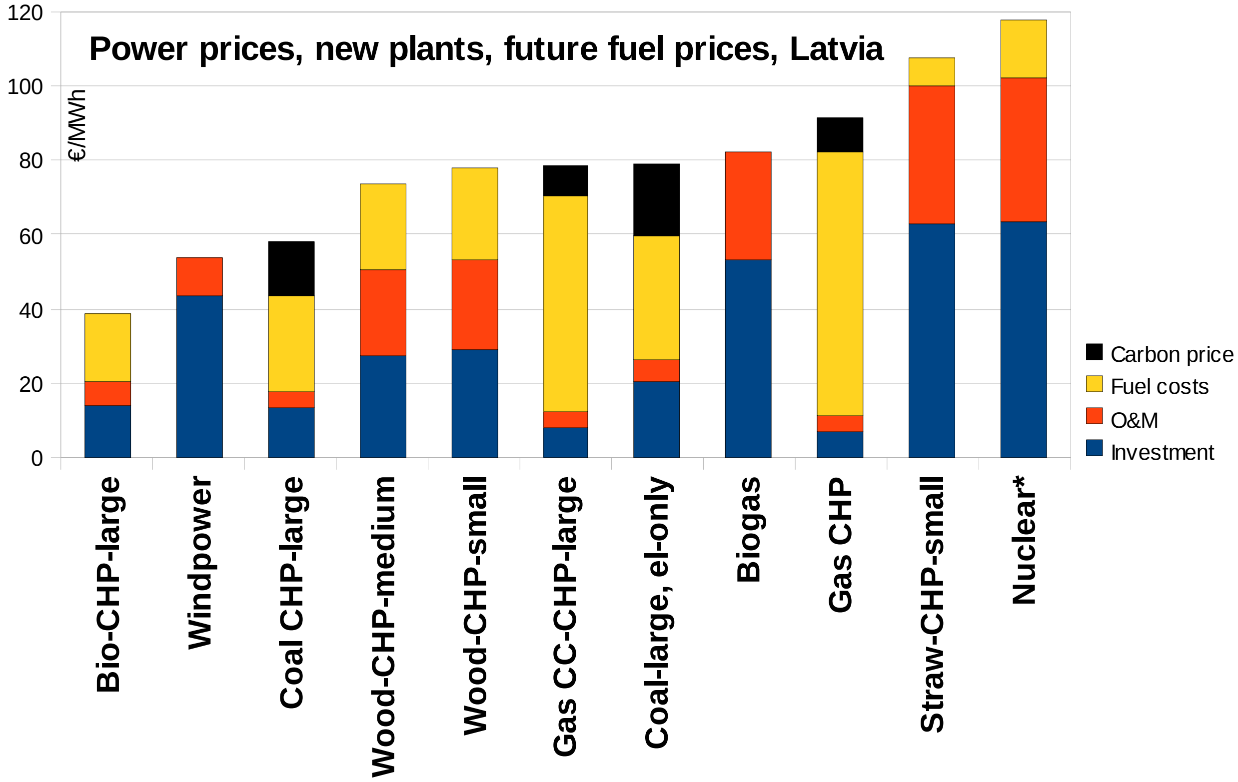


Fig.1 Costs of power plant options for possible new power plants for Latvia + nuclear with current and expected future fossil fuel prices and carbon prices, using above assumptions.

Discussion

This issue paper compares a number of power plant on equal economic terms. It give an idea of possible power costs, but in discussions of power options also other factors that costs counts. Import versus self-supply of fuels and technologies are important for the benefits a country get from choosing a particular power supply. Size also matters, in the way that larger power plants more often result in over-investments than a gradual investment in smaller power plants. Over-investment is expensive and lead to substantial higher realised power costs than in calculations as the ones presented here. Finally, unexpected costs and damages, in particular a problem of nuclear power, can substantially increase actual costs.

Annex: Assumptions and calculations used for Oil and Coal Prices

Details on oil and coal prices

Oil price: For the current oil price is taken 55 US$/barrel, based on the oil price spot market price of 52.6 US$/barrel in London, April 3, 2009 and an increasing trend of the oil spot prices since January 2009. For the future oil price the IEA in its World Energy Outlook 2008 forecast a future oil price of 100 US$/barrel in 2010 increasing to 110 in 2020 and 122 in 2030. Based on this is used a long-term price of 115 US$/barrel.

Coal: for the current coal price is used the spot market coal price for import of coal to the harbors of Rotterdam, Amsterdam and Antwerp (ARA index) that was 67 is currently 67 US$/ton and according to IEA World Energy Outlook the long-term price will be 120 US$/ton (2010 - 2015) and a possible price decline after 2015. The very high prices in 2008 (close to 200 US$/ton) indicates that cheap resources are limited, and therefore the decrease in coal prices after 2015 is not so likely. Therefore the long-term price is set to 120 US$/ton.