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 fuel costs for the immediate future (2015).

Expected Fuel Prices
Fossil fuel prices have fluctuated widely since 2008, and has been on an increasing trend since a low point in the beginning of 2009. For this evaluation is used prices for the immediate future based on prices on futures on coal and gas as well as 2015 prices for oil as forecasted by IEA[2] in its World Energy Outlook 2011: 120 US$/barrel, equal to today's price in the central (New Policy Scenario) until 2035 while in a scenario with low investments in oil exploration and continued demand growth, the oil price is set to raise to 150 US$/barrel of oil within the coming decade; in this paper is sued 120 US$/barrel. For gas prices is used the 2015 futures of the European energy exchange EEX. The price of gas futures for 2013-2015 are fluctuating in the range of 26-29 €/Mwh, at EEX. Since gas in Latvia is coming exclusively from Russia, the actual future gas price will depend on bilateral negotiations and can be both lower and higher. For coal prices is used the 2013 futures price of 122 US$/ton for the ARA index (Amsterdam, Rotterdam, Antwerp)[3] + 10% transport and distribution costs, in total 14.6 €/Mwh.

For biomass prices is used Latvian wood chip prices from mid-2008 of 7 Lat/m3 of solid wood equivalent, equal to 12.5 €/MWh. 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.

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
3 The coal-future of EEX for 2013 varied in October 2011 between 120.75 and 124.4US$/ton, thus a middle price of of 122 US$/ton is used. EEX also has coal futures for 2014 and 2015, but there is no trade in these futures on EEX and no other markets for futures after 2013, so they are not considered stable enough to base a price forecast on.

This gives the following fuel prices for current and future situations, with a €/US$ rate of 1,32:

Oil		Coal		Gas		Wood chips		Straw	
€/GJ	€/MWh	€/GJ	€/MWh	€/GJ	€/MWh	€/GJ	€/MWh	€/GJ	€/MWh
16	59	4	14,6	7,2	26	3,5	12,5	0,9	3,1

Table 1: Expected fuel prices for Latvia for the immediate future (ca. 2015)

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	**0,5**
Capacity installed	MW-th	**50**
Total investment	mill. €	25
Lifetime	years	**20**
LFCC	€/MWth	40121
O&M-1	€/MWth/year	**24000**
O&M-2	€/MWh	**0**
Eq.full load	hours/year	**5500**
O&M costs	mill €/year	1,2
Eff-total	%	**105**
Fuel costs	€/MWh	12,5
Heat costs	€/MWh heat	24
Heat costs	LAT/MWh	17

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, O&M (operating and maintenance) costs, and lifetimes are from "“Technology Data for Electricity and Heat Generating Plants”, report published by the Danish Energy Authority et.al. June 2010, with 2008-prices. 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 5% interest rate on investment.

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, 300 MW electric power, electric efficiency of 41% 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, 40 - 100 MW electric power for wood chips, 37% electric efficiency, and 100% 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).

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

Parameter	Unit	Bio-CHP-large	Wood-CHP-medium
Specific invest. Costs	mill. € / Mwe	**1,92**	**2,01**
Capacity installed	Mwe	**300**	**40**
Total investment	mill. €	576	80
Lifetime	years	**40**	**30**
LFCC	€/Mwe	111952	130623
O&M-1	€/Mwe/year	**0**	**29000**
O&M-2	€/MWh	**8,3**	**4**
Eq.full load	hours/year	**5500**	**5500**
O&M costs	mill €/year	14	2
Eff-el	%	**41**	**37**
Eff-total	%	**90**	**90**

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. June 2010, costs for investments in 2020 (in some cases average of 2010 and 2030)

LFCC = Levelised Fixed cost charge is the annual payment to cover investment costs spread equally over the lifetime and with 5% 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-medium
Investment	11	10
O&M	4	4
Fuel costs	16	14
Total	32	28

Table 4 Electricity costs from solid fuel power plants with heat selling costs of 23 €/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 investments, O&M and fuel costs is proportional to the split of costs for the entire production with heat included. The reason for the lower cost of the medium-sized plant is mainly because of the the higher heat sale because of higher total efficiency.

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 achievable 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 2,3 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 the calculation is also made with 5500 operating hours to compare with other thermal power plants, but the actual use is typically 7500 hours as the plants are used all year round and that the plant is just closed for 1.5 month during summer for maintenance etc.

		Windpower	Biogas
Specific investment costs	mill. € / Mwe	**1,25**	**3,7**
Capacity installed	MWe	**100**	**2,3**
Total investment	mill. €	125	9
Lifetime	years	**20**	**20**
LFCC	€/Mwe	100303	296898
O&M-1	€/Mwe/year	**0**	**0**
O&M-2	€/MWh	**12**	**30**
Eq.full load	hours/year	**2000**	**5500**
O&M costs	mill €/year	02-04-12	0.4
Eff-el	%	n.a	46
Eff-total	%	n.a	92

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.

Data are taken from "Technology Data for Electricity and Heat Generating Plants", Danish Energy Agency, June 2010.

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
Investment	50	39
O&M	12	22
Total	62	61

Table 6 Electricity costs from windpower and from biogas plants with heat selling costs of 23 €/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 100 MW CHP plant with an electric efficiency of 46% and a 200 MW combined-cycle CHP plant with an electric efficiency of 57%. For coal-fired plants are included a 400 MW CHP plant with an electric efficiency of 41% and a 400 MW power-only plant with an efficiency of 49%. 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	0,57	0,51	1,65	1,4	5,24
Capacity installed	MWe	100	200	400	400	1000
Total investment	mill. €	57	101	660	560	5240
Lifetime	years	25	25	40	40	50
LFCC	€/MWe	40443	35831	96159	81589	305378
O&M-1	€/MWe/year	9000	0	0	0	0
O&M-2	€/MWh	3	4,5	8,3	7	7
Eq.full load	hours/year	5500	5500	5500	5500	5500
O&M costs	mill €/year	2,7	5	18	15	39
Eff-el	%	46	57	41	49	n.a.
Eff-total	%	83	90	90	49	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", Danish Energy Agency, June 2010.

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	5	5	10	15	52
O&M	3	3	5	7	7
Fuel costs	40	34	20	30	16
Carbon costs	5	4	8	10	

Total	54	47	42	62	75

Table 8 Costs of fossil and nuclear power plant option with near-future prices of fuels and expected data for 2020. For fossil fuel-fired plants is included a carbon cost of 15 €/ton.

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 4 €/MWh to 79 €/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 general calculations):

		Bio-CHP-large	Wood-CHP medium	Bio-gas	New Gas CC-CHP	New Coal, el-only	Nuclear
Costs @ 5500 h/y	€/ MWh	32	28	62	47	62	75
Costs @ 7500 h/y all heat is sold	€/ MWh	26	20	47	41	48	61
Costs @ 7500 h/y 3/4 of heat is sold	€/ MWh	32*	30*	53	44	48	75

Table 9 Costs of power production at full load hours of 5500 and 7500 hours/year.
* Plants are only run when it is cost-effective, which is less than 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 biomass plants that get largest income from heat sale.

Comparing the Options

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

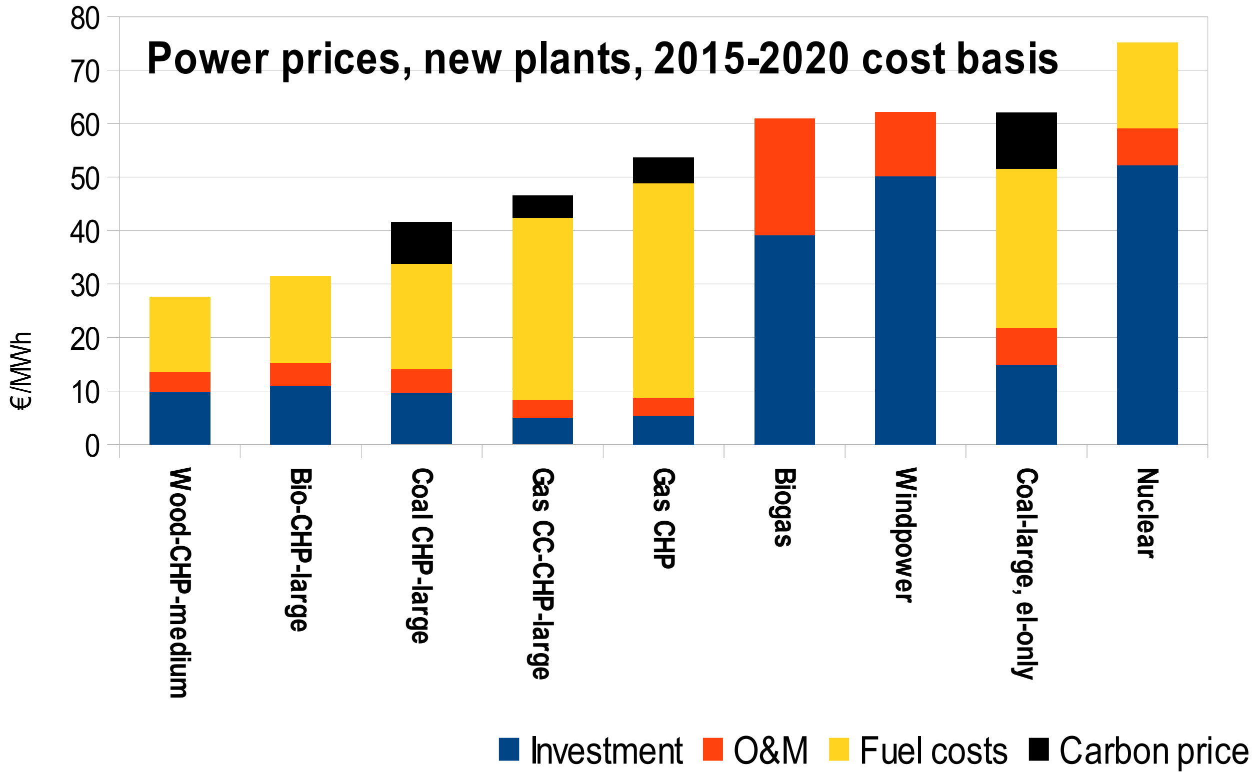

Fig.1 Costs of power plant options for possible new power plants for Latvia + nuclear with expected near-future fossil fuel prices and carbon prices of 15 €/ton, using above assumptions.

Discussion

This issue paper compares a number of power plant on equal economic terms. It gives 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.