Bioenergy Potential in Kaluga Region

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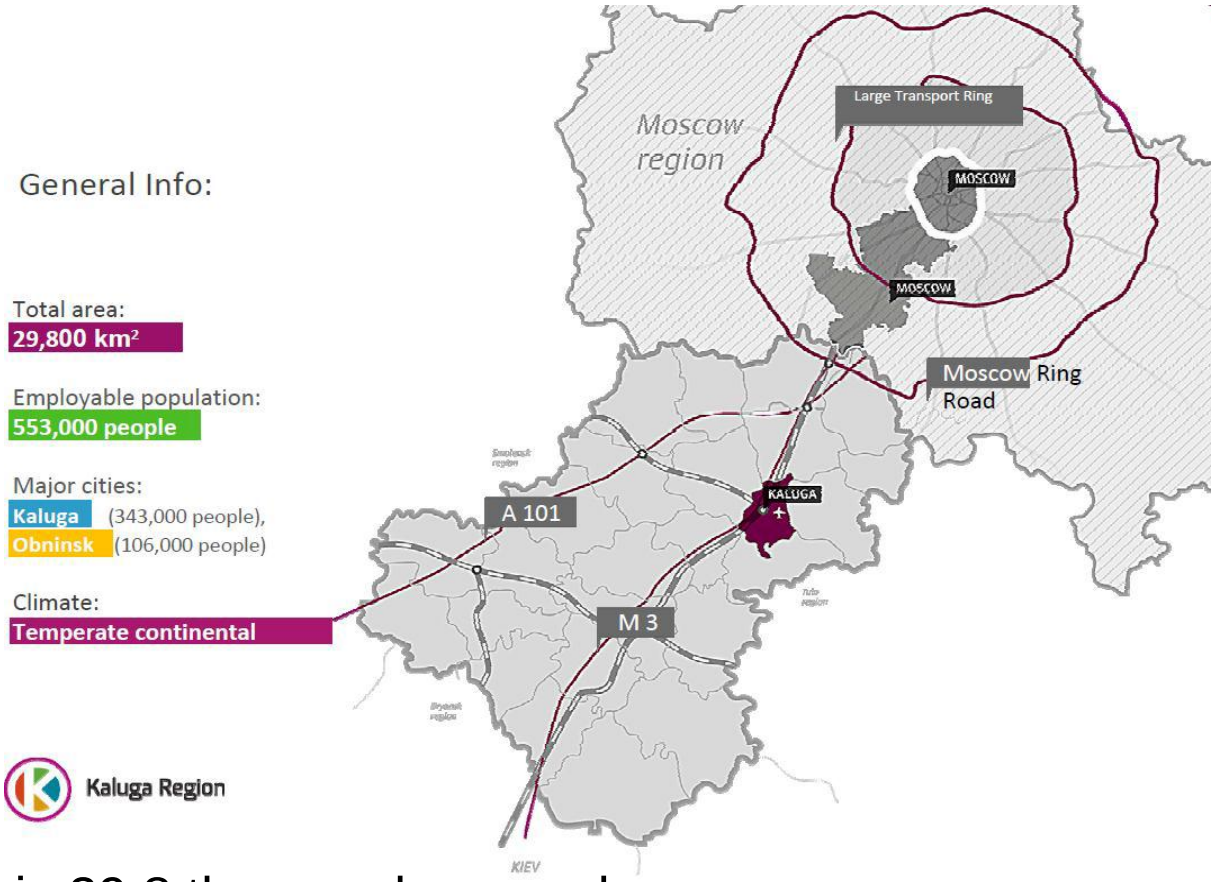
09/10/2012

The Netherlands

Kaluga Region on the map of Russia



Area is 29.8 thousand square km

Population is 1009.9 thousand people (2011)

Energy Supply of Kaluga Region

Total electricity consumption – 4761 million kWh (2010)

Only 339 million kWh (7%) of electricity is produced in Kaluga region itself (2010)

Main fuel is natural gas – 95% of total fuel balance

Natural gas consumption – 1061.6 million m^3 (2011)

All natural gas is delivered from other regions of Russia

Portion of renewables is negligibly small

Main Preconditions for Renewable Energy Development in Kaluga Region

- growth in electricity demand with a shortage of own generation
- increasing dependence on energy resources (fossil fuels and electricity) from outside the region
- demand for "green" energy from foreign investors which dispose its production facilities in Kaluga region
- quite developed agriculture and food industry, respectively large amount of waste
- possibility to create new high-tech jobs

Bioenergy Potential in Kaluga Region

Specification by:

- *kinds of biomass* – manure from various animals, straw of various cereal crops, wood wastes, food waste, waste water, energy crops, etc.
- *types of technology* – direct combustion, gasification, anaerobic digestion, pelletization
- *locality* – 25 districts and about 200 separate enterprises

Bioenergy Potential in Kaluga Region

For each chosen combination of
kind of biomass / technology type / locality
***we determined*:**

- natural amount of biomass (ton or m^3)
- fuel equivalent of biomass (ton of coal equivalent*)
- amount of heat if biomass is used for heat generation only (Gcal)
- amount of electricity and heat if biomass is used in cogeneration mode (MWh and Gcal)

* t.c.e.=29.3 GJ

Bioenergy Potential in Kaluga Region

Kind of biomass	Fuel, t.c.e.	Heat only, Gcal	Cogeneration	
			Power, MWh	Heat, Gcal
Total with energy crops	**733 216**	**3 401 371**	**1 827 623**	**1 388 188**
Energy crops	**439 137**	**1 844 375**	**1 251 612**	**461 094**
Total without energy crops	**294 079**	**1 556 996**	**576 011**	**927 094**
Animal waste	88 308	408 615	209 997	177 592
Crop waste	72 985	376 545	130 630	234 152
Wood waste	92 452	517 730	120 424	388 297
Gas from landfills	34 552	217 679	98 480	108 840
Gas from waste water	5 782	36 427	16 480	18 213

From Potential towards Economics

- ✓ ***How to determine "green" tariff?***
- ✓ ***And is there a simple tool for quick estimation of energy price in the first approximation at least?***

<u>Important condition:</u> **IRR should be equal to discount rate specified by an investor (for ex. 12% not including inflation).**

In this case NPV=0 and thus we determine the minimal selling price satisfying an investor

From Potential towards Economics

Special research for wood waste has been carried out

Quite simple dependences (graphs and equations) for calculation of selling price for energy generated from wood waste (fuel chips out of forest residues) have been developed

Three technology schemes were considered:

1. **Boiler house with combustion**
2. **Steam-turbine CHP plant with combustion**
3. **Gas-piston engine CHP plant with gasification**

From Potential towards Economics

Main input parameters:

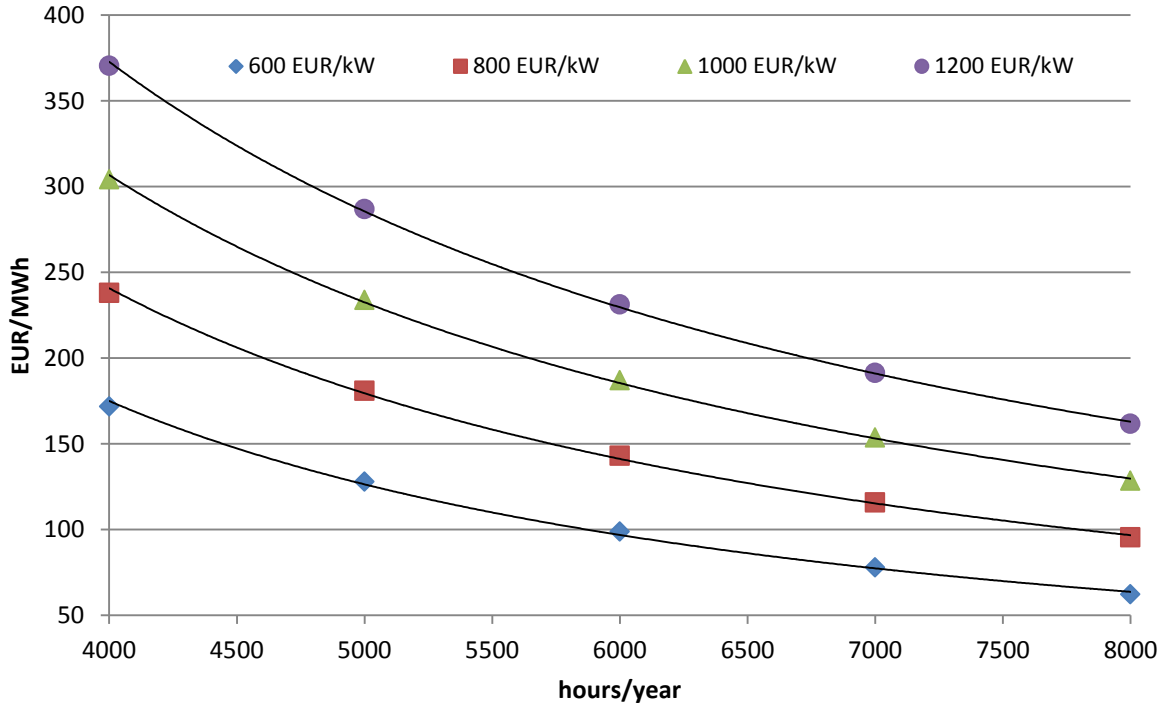
- **specific capital investments (per kW);**
- **number of hours of use of installed capacity;**
- **price of wood fuel without delivery;**
- **average delivery distance of wood fuel;**
- **cost of delivery of wood fuel;**
- **selling price of heat (for cogeneration plants);**
- **net electrical efficiency;**
- **discount rate;**
- **specific reduction of GHG emissions per unit of fuel energy;**
- **price of GHG emission reductions.**

From Potential towards Economics

Example for steam-turbine CHP plant

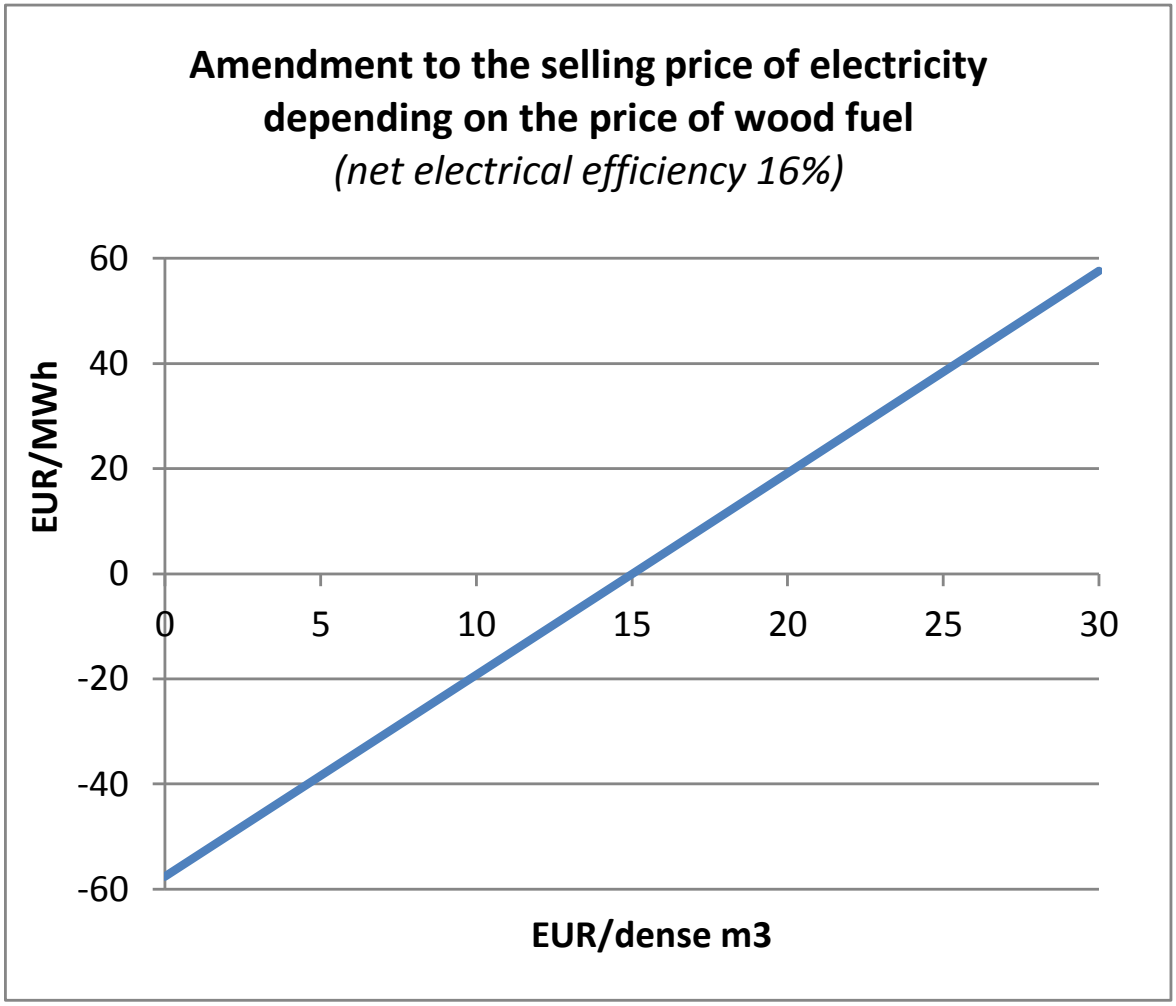
The selling price of electricity when $NPV_{12\%} = 0$ depending on the specific capital investments per heat capacity of boilers and the number of hours of use of installed capacity

*(selling price for heat 30 EUR/Gcal, price of wood fuel without delivery 15 EUR/dense m3, delivery distance 50 km, shipping 0.0875 EUR/(t*km), net electrical efficiency 16%, excluding "carbon" component)*



From Potential towards Economics

Example for steam-turbine CHP plant



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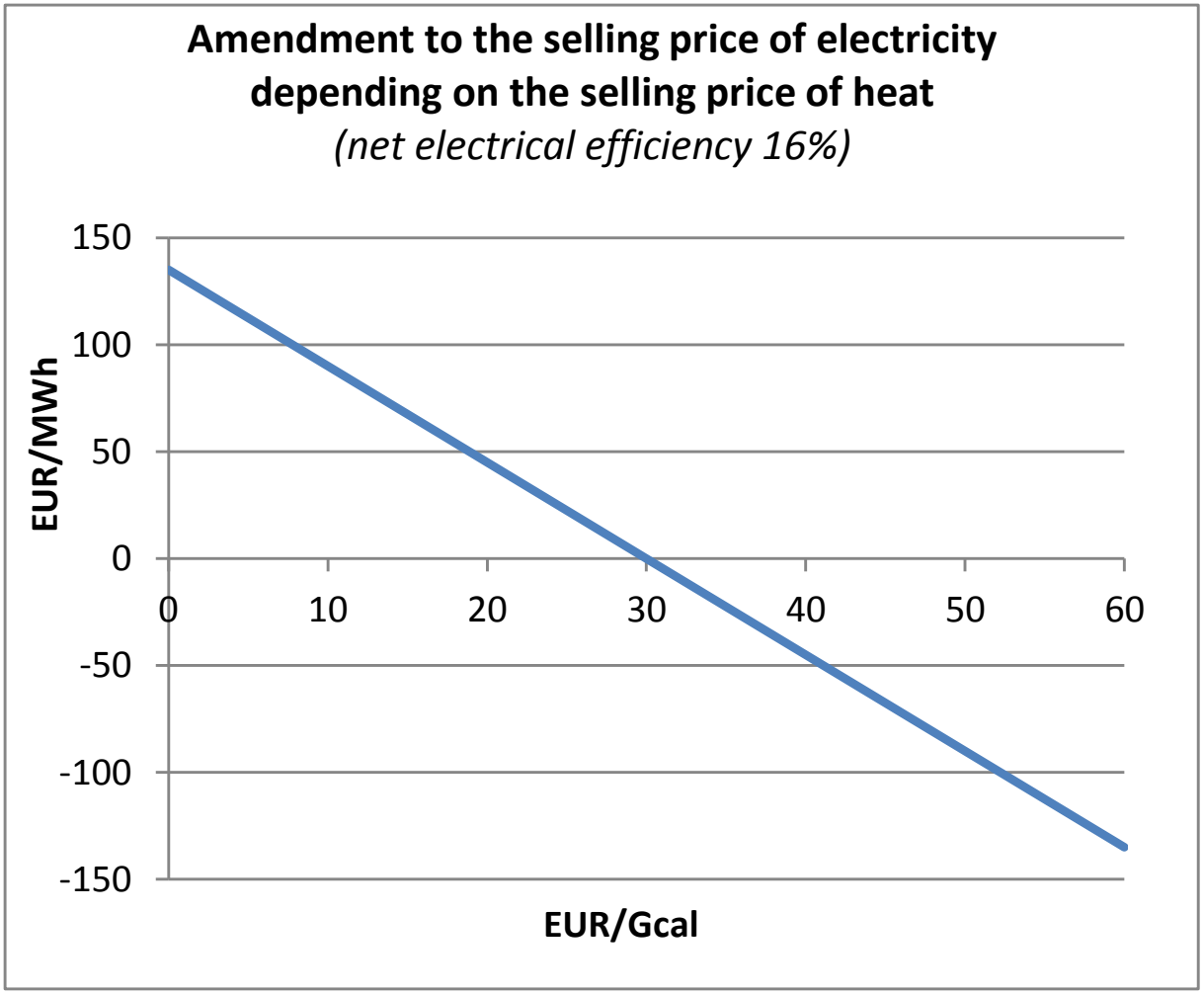
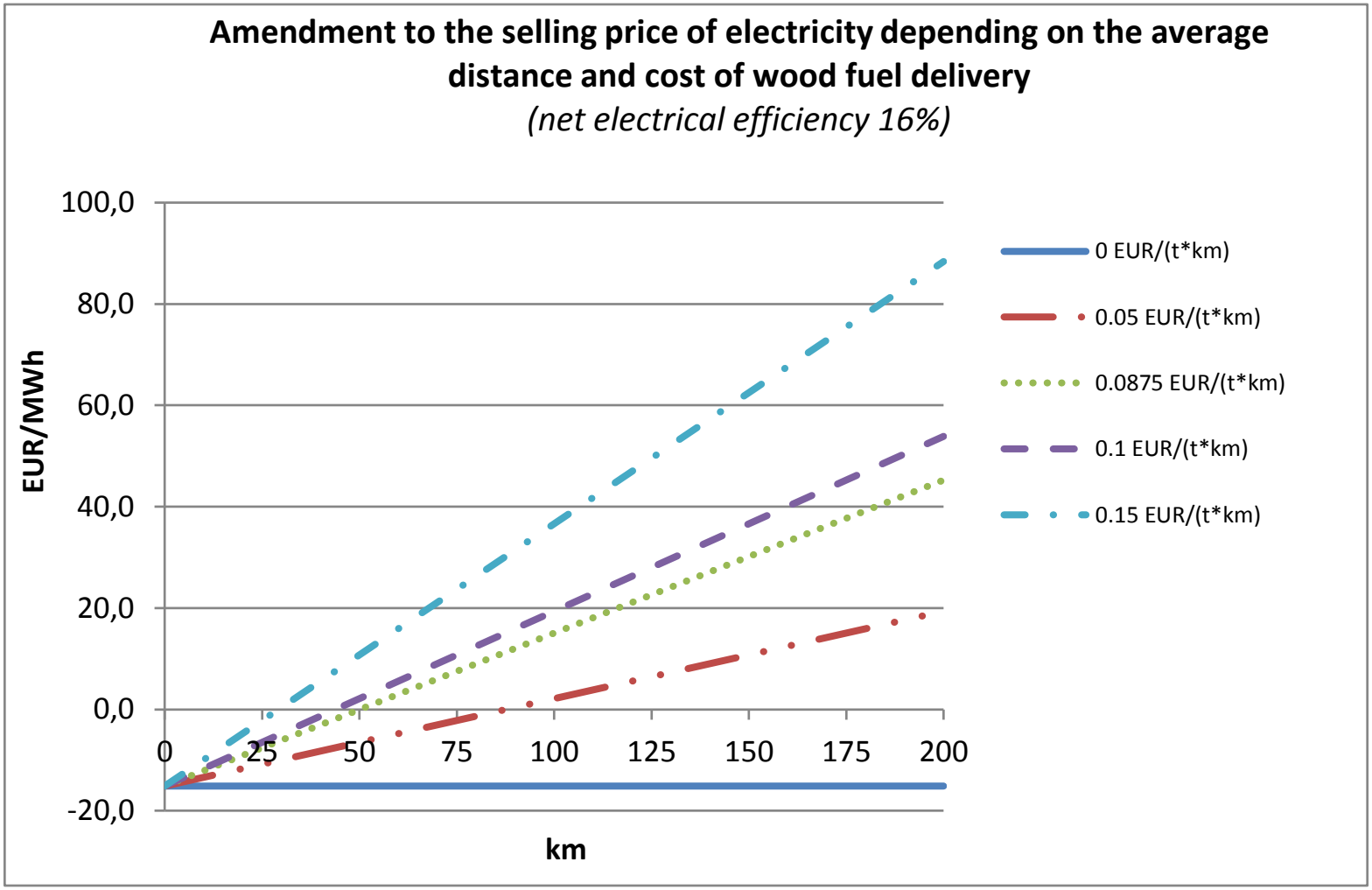
Example for steam-turbine CHP plant



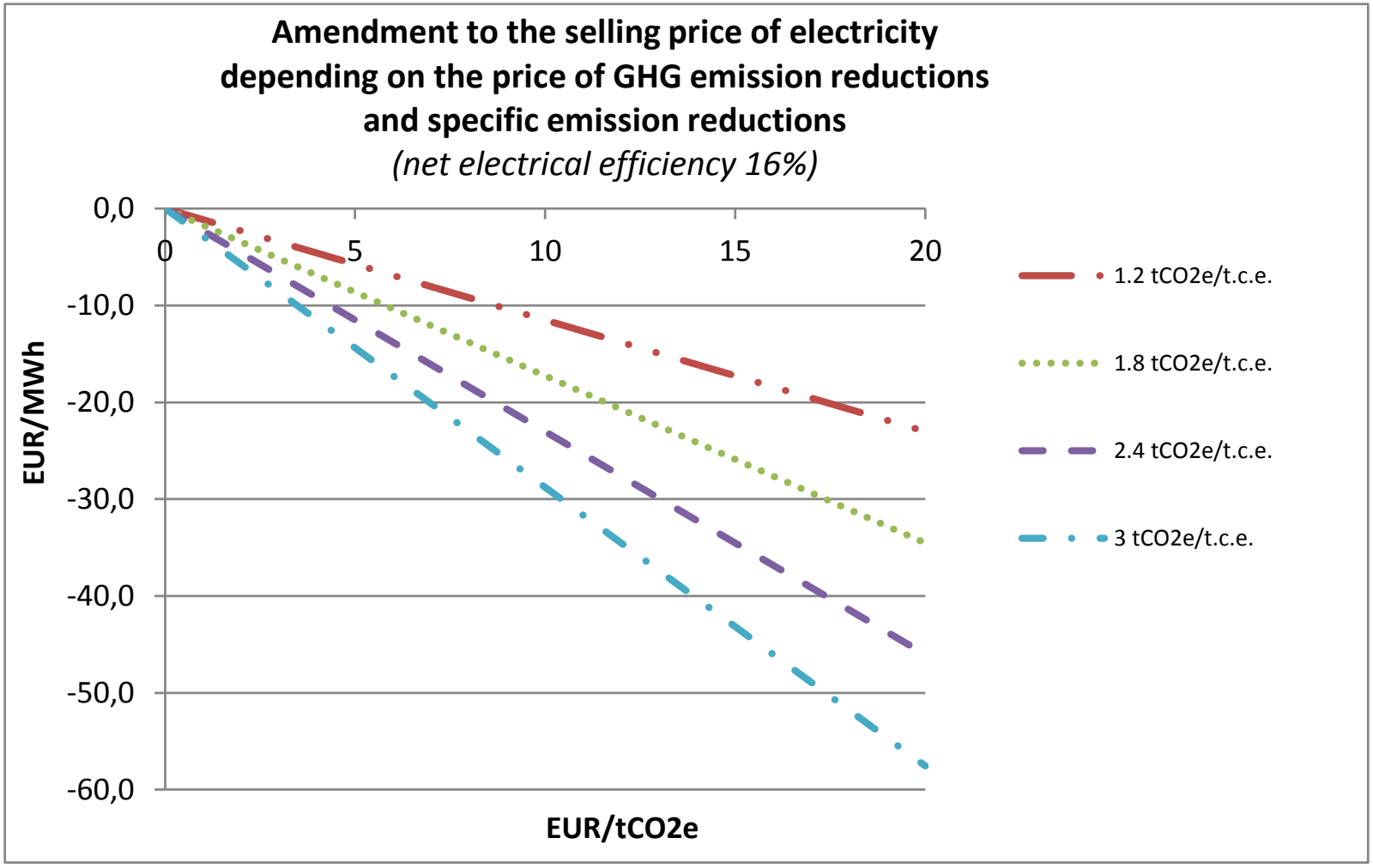
From Potential towards Economics

Example for steam-turbine CHP plant



From Potential towards Economics

Example for steam-turbine CHP plant

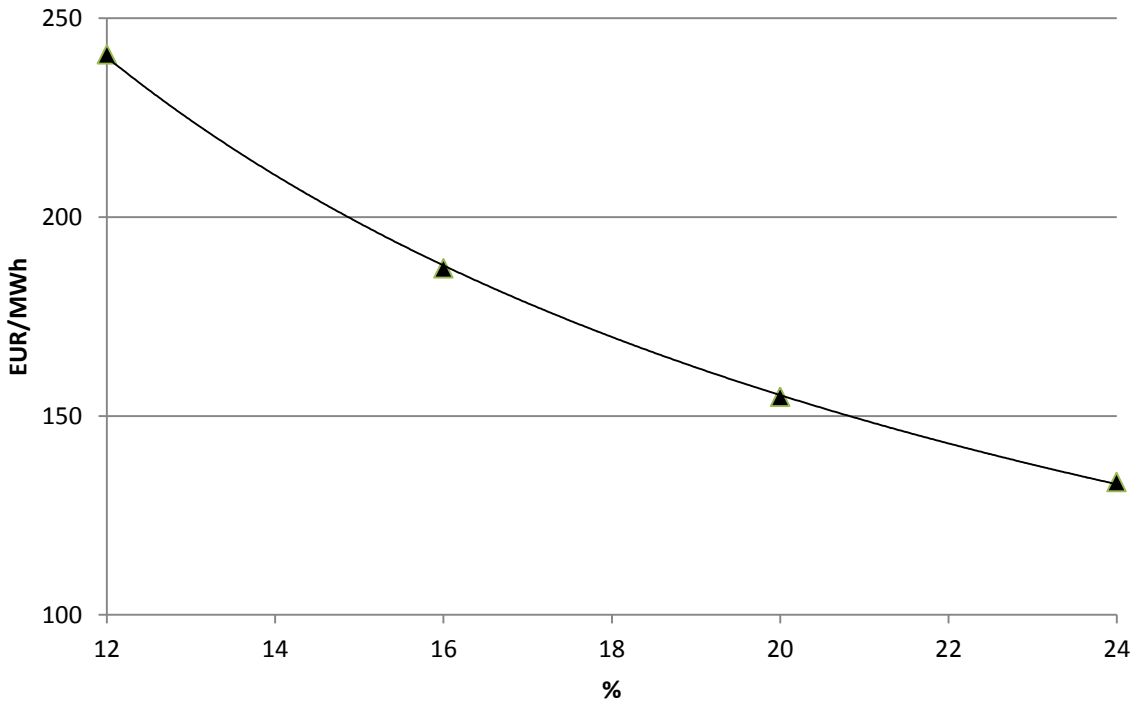


From Potential towards Economics

Example for steam-turbine CHP plant

The selling price of electricity when $NPV_{12\%} = 0$ depending on the net electrical efficiency

*(selling price for heat 30 EUR/Gcal, price of wood fuel without delivery 15 EUR/dense m3, delivery distance 50 km, shipping 0.0875 EUR/(t*km), specific capital investments per heat capacity of boilers 1000 EUR/kW, number of hours of use of installed capacity 6000 h/y, excluding "carbon" component)*



From Potential towards Economics

Example for steam-turbine CHP plant

Approximate equation:

$$p_e = \frac{16}{\eta_e} \times \left[546 \times \frac{k_{hb}}{t} \times (1 + 0.13 \times d) + 3.84 \times p_f + 3.45 \times p_s \times s - 4.5 \times p_h - 0.96 \times r_{GHG} \times p_{GHG} \right] + 22$$

where p_e - selling price of electricity, EUR/MWh;

p_h - selling price of heat, EUR/Gcal;

k_{hb} - specific capital investments per heat capacity of boilers, EUR/MW;

t - number of hours of use of installed capacity, hours;

d - discount rate, %;

p_f - price of wood fuel, EUR/dense m^3;

p_s - cost of delivery of wood fuel, EUR/(t*km);

s - average delivery distance for wood fuel, km;

r_{GHG} - specific reduction of GHG emissions per unit of fuel energy, tCO_2e /t.c.e.;

p_{GHG} - price of GHG emission reductions, EUR/tCO_2e;

η_e - net electrical efficiency (share of heat generated in boilers transformed into net power), %.

From General Economics to Cases

Map of location of energy sources, working in forest residues, and the corresponding group of districts where residues are collected

From General Economics to Cases

Eitght variants were calculated for each of chosen energy sources

Results for Kondrovo:

Parameter	Unit	Values							
		Boiler house		Steam-turbine CHP plant			Gas-piston CHP plant with gasification		
	Variants:	A-1	B-1	C-1	D-1	E-1	F-1	G-1	H-1
Selling price for electricity	EUR/MWh	-	-	75,0	**271,3**	**199,2**	75,0	**232,2**	**203,1**
Selling price for heat	EUR/Gcal	30,0	**46,0**	30,0	30,0	46,0	30,0	30,0	46,0
IRR	%	**0,1**	14,0	**0,0**	18,0	18,0	**-0,3**	22,00	22,00
Payback period	year	**>16**	>7	**n/a**	>6	>6	**n/a**	>5	>5

Figures in bold script are sought parameters

About Company

CCGS LLC (Climate Change Global Services) is the leading provider of services and solutions in the sphere of energy and climate change, including development of all kinds of investment projects aimed to energy efficiency, renewable energy and GHG emission reduction using mechanisms of Kyoto protocol and other carbon market mechanisms.

The Company has more than 25 JI (Joint Implementation) projects successfully developed and validated under the Article 6 of Kyoto protocol. The total expected potential of ERUs (emission reduction units) is about 48 million t CO_2-equvivalent. To date the amount of monitored ERUs is about 25 million t CO_2-equvivalent.

In 2012 CCGS was accredited as official service provider for the World Bank Group and in the same year the agreement with IFC (International Finance Corporation) on biomass potential estimation in Kaluga region of Russia was signed.

About Company

The biggest Russian companies are our clients: LUKOIL, NOVATEK, EVRAZ, TMK, Quadra, ILIM group, Arkhangelsk PPM, International Paper (Svetogorsk), Volga, Solombala PPM, Sawmill 25, Kronostar and others.

The Company is a part of the international CCGS Holding with the headquarter in Brussels and offices in Russia (Moscow and Arkhangelsk), South Africa (Cape Town) and South-Eastern Asia (Singapore).

Besides Russia we also develop business in Kazakhstan, Ukraine and Belarus.

CCGS employs highly qualified personnel with a unique carbon and energy experience. The main CCGS' technical team (energy and oil&gas engineers) works in Arkhangelsk.

Some of people working now at CCGS have unique experience of organization of investment in Russia's biomass and energy saving projects with use of World Bank loans as far back as in 90s. These are projects at Arkhangelsk PPM and Solombala PPM.

About Company

We are mainly engaged in organizing carbon financing of a wide number of projects, including use of biomass for power and heat generation. All JI PDDs (project design documents) are available at our website **www.ccgs.ru**

Recently singed agreement with IFC on biomass potential in Kaluga region opens new horizons of our activity.

We plan to work in the similar direction for Belgorod, Arkhangelsk, Tomsk regions.

We are interested in establishing long-term relationships with banks and other financial institutions, above all in Europe, to mobilize financial resources for implementation of projects and programs in the sphere of energy efficiency and bioenergy using the most modern European and Russian technologies.

Thank you for attention!

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