Pilot Study on Cost Analysis applied to the Apatity Power station

Preliminary results

Cooperation with the Coordinating Group on the promotion of actions towards implementation of the Convention in Eastern Europe, the Caucasus and Central Asia

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EGTEI cooperation with the Coordinating Group for Eastern Europe, the Caucasus and Central Asia

In the scope of the cooperation with the Coordinating Group on the promotion of actions towards implementation of the Convention in Eastern Europe, the Caucasus and Central Asia led by the Russian Federation (the Scientific Research Institute for Atmospheric Air Protection SRI insuring the coordination of the group), the following actions have been set up :

✓Carry out a pilot study on emission abatement cost assessment for electricity generation in the Russian Federation. Other sectors could follow such as oil, non-ferrous metal industries…

✓Participate to a joint session of the Coordinating Group for Eastern Europe, the Caucasus and Central Asia and the Expert Group within the Atmosphere-2012 Congress ,

✓Translate the relevant documents on techno-economic issues into the Russian language. (Presently, the revised guidance document attached to the Gothenburg protocol is being translated).

Apatity combustion plant SO_2, NOx and dust emissions reduction cost assessment

Aim of the study:

Determine costs of reduction techniques to abate SO_2, NOx and TSP from a power plant based on the methodology developed by EGTEI for Large Combustion Plants

Characteristics of the Apatity Power Plant

Combustion plant with 10 boilers, with a total rated thermal input of 1530 MWth
Each boiler with the same capacity : 153 MWth

Production of heat and power, in 2010 :
- ✓ Electricity generation : 430 GWh
- ✓ Heat output : 1279.6 Tcal

Characteristics of coals consumed:

Type	Low calorific value	Ash content in operating conditions	Fuel consumption 2008	Fuel consumption 2010
	GJ/t	% w/w	Tons	Tons
Intinskiy (Sub bituminous)	22.80	27.39	225 069	62 350
Vorkutinskiy (Sub bituminous)	22.62	21.37	0	167 386
Kuznetskiy (Bituminous)	17.81	16.77	212 623	171 324
Fuel oil	39.90		655	645
Total			**438 347**	**401 705**

Characteristics of the Apatity Power Plant

Combustion plant with 10 boilers, with a total rated thermal input of 1530 MWth
Each boiler with the same capacity : 153 MWth

	Rated thermal input of the boiler MWth	Presence of a venturi scrubber	Ducts per boiler	Stack
Boiler n°1	153	1	1	Stack 1
Boiler n°2	153	1	1	
Boiler n°3	153	1	1	
Boiler n°4	153	1	1	
Boiler n°5	153	1	1	Stack 2
Boiler n°6	153	1	1	
Boiler n°7	153	1	1	Stack 3
Boiler n°8	153	1	1	
Boiler n°9	153	1	1	
Boiler n°10	153	1	1	

Emissions of pollutants

Each boiler equipped with a venturi scrubber for the removal of dust

Monitoring results available, one example:

Total emissions of boiler N°5 during monitoring	g/s	kg/t coal	kg/GJ	Efficiency of the wet scrubber
Dust before venturi scrubber	1 560	240.0	10.91	
Dust after venturi scrubber	116	17.9	0.81	92.6%
NOx	30	4.6	0.21	
SO_2	145	22.3	1.01	

Emissions of pollutants

Total emissions of the Apatity plant:

Total emissions	2008 tons	2010 tons
Dust before venturi scrubber	91 329	84 593
Dust after venturi scrubber	6 472	5 995
NOx	2 440	2 260
SO_2 based on a sulphur content of coals of 1.5 %	13 096	12 131

Emissions of pollutants

Average emissions taken into account for calculation

Average emissions for the two boilers	**kg/t coal + heavy fuel**	**kg/GJ**	**mg/m^3 STP and 6 % O_2**
Dust before venturi scrubber	209.4	10.21	30 455
Dust after venturi scrubber	14.8	0.724	2158
NOx	5.6	0.273	814
SO_2	30.0	1.464	4 367

Emission reductions tested

Comparison of the emissions of the Apatity plant with option 1 to 3 of technical annexes IV, V and X revised

	Average concentration	Option 1	Option 2	Option 3
	mg/m³ STP and 6 % O_2			
Dust before venturi scrubber	30 455	10	20	50
Dust after venturi scrubber	2 158	10	20	50
NOx	814	100	200	200
SO_2	4 367	100	200	1 200

Efficiency required:
SO_2: 95.4 %
NOx: 75.4 %
TSP: 99.9 % (the scrubbers are not kept in operation)

Reduction techniques used for the cost assessment

A chain **SCR** (Selective Catalytic Reduction) to remove NOx, **ESP** (Electrostatic Precipitator) to remove dust and **wet FGD** (Flue Gas desulphurisation) is taken into account

Due to low temperature after the scrubbers (less than 70 °C), they are not kept in operation to avoid reheating of flue gases for the SCR (to 300° to 400°C)

The cost evaluation is carried out for the following chain:

✓ Each boiler is equipped with its own SCR unit, followed by an ESP.

✓ After the ESPs, waste gases are collected and directed towards a unique FGD unit. The FGD is with forced oxidation. Gypsum can be recovered.

Estimation of costs of reduction techniques

- **Investments (INV : k€ or M€):**

Amount paid for the reduction technique ready to be used – Retrofit factor for existing installations

- **Annualised capital costs (ACC : k€/y):**

Investments annualised taking into account the interest rate and the life time of the equipment

- **Fixed operating costs (OC$_{fix}$: k€/y):**

Costs of maintenance and repair, administrative overhead, etc.

- **Variable operating costs (OC$_{var}$: k€/y):**

Depending on the technique: costs of electricity, reagents ($CaCO_3$, NH_3, CaO), water, waste disposal...

- **Total annual costs: (C$_{tot}$: k€/y):**

$C_{tot} = ACC + OC_{fix} + Oc_{var}$

Estimation of costs of reduction techniques

✓ **Investments (INV : k€ or M€):**

The available investment functions have been updated taking into account recent data on costs in the literature, and to have costs expressed in € of 2010,

✓ **Annualised capital costs (ACC : k€/y):**

Investments annualised taking into account the interest rate of 4 % as in EGTEI but to be discussed with SRI,

Life time of the equipment of 15 years, also to be discussed with SRI

✓ **Fixed operating costs (OC_{fix} : k€/y):**

Costs estimated to 4 % of the investments.

Estimation of costs of reduction techniques

✓ **Variable operating costs (OC_{var} : k€/y):**

- labour demand,
- electricity consumption,
- water consumption,
- chemical consumption (reagent such as $CaCO_3$, NH_3...)
- byproduct cost (discharge) / profit (when sold gypsum...)),
- ...

Use of the cost functions developed by EGTEI with update for some criteria

Estimation of costs of reduction techniques

✓ **Prices used for definition of variable operating costs:**

The prices of utilities, wages, and reagents taken into account are as follows :

Electricity: 0.1 €/kWh

Wages: 6 k€/person/year

Waste disposal: 8.3 €/t

Lime stone: 20 €/t $CaCO_3$. Cost assumed to be similar to costs in the EU.

NH_3: 400 €/t NH_3. Cost assumed to be similar to costs in the EU

SCR catalyst : 20000 €/m^3

…

Cost assessment
Preliminary results

	SO_2	NOx	TSP
Investments - k€ $_{2010}$	63 559	62 868	30 734
Operating cost - k€ $_{2010}$ / year	5 013	2 890	2 148
Total annual costs - k€ $_{2010}$/year	10 730	9 718	4 912
Initial annual average emissions - tons	12 612	2 352	87 961
Emissions abated - tons	12 034	1 764	87 903
Pollutants emitted - tons	578	588	58
Cost € $_{2010}$/t pollutant abated	892	5 509	56

Cost assessment : conclusions

Costs probably underestimated as, with the EGTEI methodology, only average investment costs of reduction techniques are estimated.

Degree of complexity of the retrofit not exactly known in the scope of this study. Average retrofit factors have been used.

Investments can increase with the degree of the difficulty. Availability of place on the site after each boiler to install a SCR unit and an ESP not known.

The configuration adopted requires a huge change in the flue gas handling. All these changes require adaptations of controls of the plant.

The study carried out cannot replace a detailed site specific engineering cost study but provides useful information for the assessment of the economical impact of a regulation