

PRELIMINARY RESULTS: NOT FOR CIRCULATION OR QUOTING

THE COSTS AND HEALTH BENEFITS OFAPPLYING

REDUCING EMISSIONS FROM POWER STATIONS IN EUROPE

for the Swedish NGO Secretariat on Acid Rain

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Best Available Technique Emission Control Technology

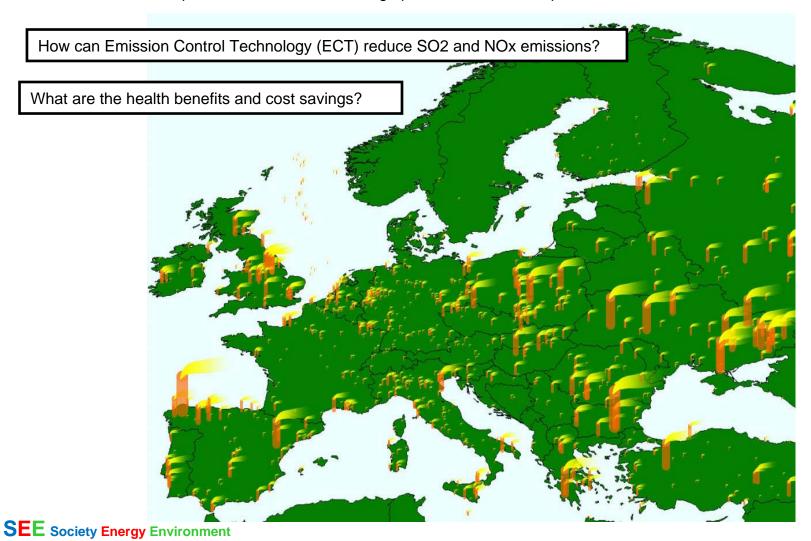
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Large Point Sources of Emissions

SO2 emissions from power stations and other large point sources in Europe and western Asia.





Analytic process

- 1. Assemble and reconcile data:
 - Facilities (power stations)
 - Emissions (European Pollution Emission Register)
 - Best Available Technique Emission Control Technologies (BATECT)
- 2. Estimate costs and emission reductions of applying BAT

3. Estimate health impact and cost benefits of emission reductions - Mike Holland of EMRC



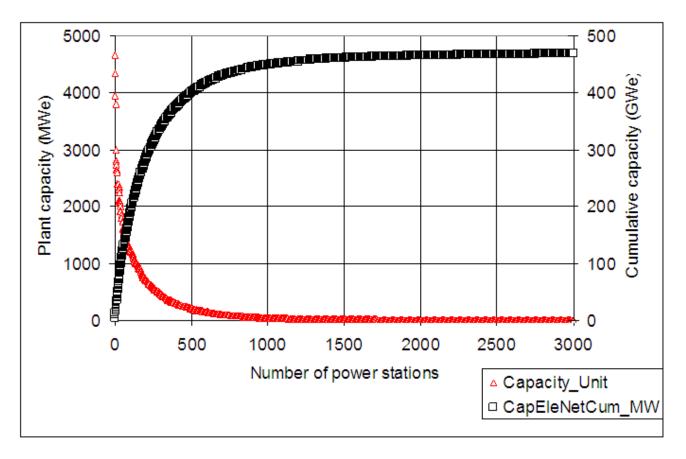
Scope

- Aim is to reduce emissions of SO2 and NOx from power stations in Europe
 - Other pollutants not included: primary PM, mercury, etc.
- Best Available Technique Emission Control <u>Technologies</u> (ECT) such as:
 - boiler modification
 - flue gas treatment with Flue Gas Desulphurisation (FGD)
 - flue gas treatment with Selective Catalytic Reduction
- Emission control measures <u>not</u> included in this study:
 - Changing fuel or fuel quality
 - Switching generation from worse plants to better plants
 - Reducing electricity demand
 - Increasing renewable generation



Wider Europe : fossil fuelled power stations - number and capacity

- About 4000 power plant with a total capacity of 460 GWe
- Largest 130 stations account for about 50% of capacity
- Largest 500 stations account for about 85% of capacity





BAT Emission Control Technologies (BATECT)

Many factors affect emission reduction and costs

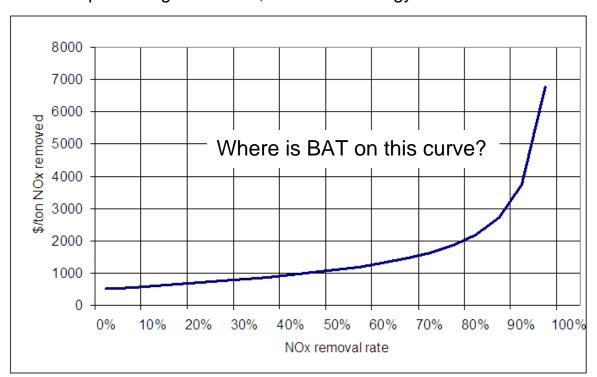
Plant	plant size (MWe/MWth)						
	plant technologies (fuel preparation, boilers, etc.)						
	site and plant internal/external layout and characteristics						
	whether ECT is for a new plant, or retrofitted						
	pre-existing ECT such as low-NO _x boilers or FGD						
	the anticipated remaining plant life						
	the exhaust gas concentrations of SO ₂ , NO _x , metals, etc. prior to control						
Fuel	fuel characteristics (coal, oil, gas, sulphur, nitrogen, ash, mercury, etc.)						
Operation	the operating regime of the plant: annual capacity factor (average output / maximum output); plant cycling						
	the effect of ECT on plant energy efficiency including the requirement for power to run ECT						
Inputs	costs of materials for pollution removal (limestone, catalysts etc)						
Outputs	markets for by-products (e.g. gypsum, sulphuric acid)						
	waste disposal						
Other	local environmental considerations						





What is BAT – Best Available Technique?

Illustrative curve for SCR: Removal costs (\$/tonne) increase with percentage removed, and so do energy and CO2 costs.



Should SCR be BAT for gas power stations? It is used extensively in Italy and California.

Should BAT vary by circumstances in different countries and locations?



BAT Emission Control Technologies (ECT) - BATECT

Assumed performance and costs for BATECT applied to large (>500 MWe) power stations.

For NOx, combinations of boiler and flue gas measures achieves least cost emission control.

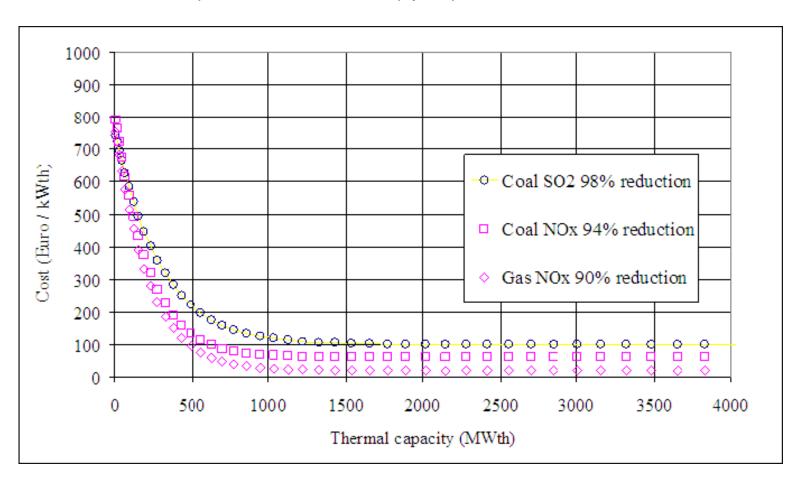
				Efficiency	Capital	O&M costs	
Pollutant	Fuel	Technology R	eduction	loss	Euro/kWth	Euro/kWth/a	Euro/kWhth
SO2	Oil	FGD	98%	2.5%	90	2.00	1.00
	Coal	FGD	98%	2.5%	100	2.00	1.00
NOx	Gas	SCR	90%	0.5%	20	1.50	0.50
	Oil	Boiler+SCR	92%	0.5%	20	1.65	0.55
	Coal	Boiler+SCR	94%	0.5%	60	1.80	0.60





BAT Emission Control Technologies (ECT) - BATECT

Economies of scale: capital costs increase sharply as plant size diminishes.





BATECT - application

Assume BATECT applied to all power stations.

Calculate emission reduction

Calculate capital and running costs - annuitise capital at 4 %/a discount rate over 15 years.





EU27: first 20 largest SO2 emitters

Plants in **bold** have emissions data from European Pollution Emission Register (2004)

	Cou	Plant	MWe		Ash rem %	ECT	Rem %	Base kt	Red %	Emit post BAT kt	Euro /t
1	BGR	Maritsa II	1450	Coal	30%	FGD	40%	332	59%	8	169
2	ESP	Puentes	1400	Coal	30%		30%	312	69%	6	229
3	GRC	Megalopolis	1400	Coal	30%	FGD	52%	209	46%	6	167
4	ESP	Teruel	1050	Coal	5%	FGD	95%	163	3%	65	289
5	POL	Belchatow	4340	Coal	30%	FGD	72%	140	27%	7	1069
6	BGR	Maritsa I	200	Coal	30%		30%	96	69%	2	163
7	POL	Patnow	1200	Coal	30%		30%	88	69%	2	655
8	GBR	Cottam	2008	Coal	5%		5%	67	93%	1	1432
9	ESP	Meirama	550	Coal	30%		30%	63	69%	1	345
10	ESP	Compostilla	1312	Coal	5%		27%	62	72%	2	1019
11	POL	Kozienice	2600	Coal	5%	FGD	85%	57	13%	7	997
12	PRT	Sines	1256	Coal	5%		5%	57	93%	1	1211
13	ESP	La Robla	620	Coal	5%		5%	57	93%	1	585
14	ROM	Craiova	240	Coal	30%		30%	56	69%	1	283
15	ROM	Turceni	2310	Coal	30%		30%	52	69%	1	1393
16	POL	Rybnik	1720	Coal	5%	Inj	48%	48	50%	2	1315
17	EST	Eesti	1610	\mathbf{S}	10%		10%	47	88%	1	1423
18	BGR	Bobovdol	630	Coal	30%		30%	47	69%	1	530
19	ROM	Drobeta	200	Coal	30%		30%	45	69%	1	340
20	HUN	Oroszlnany	235	Coal	5%		5%	45	93%	1	389



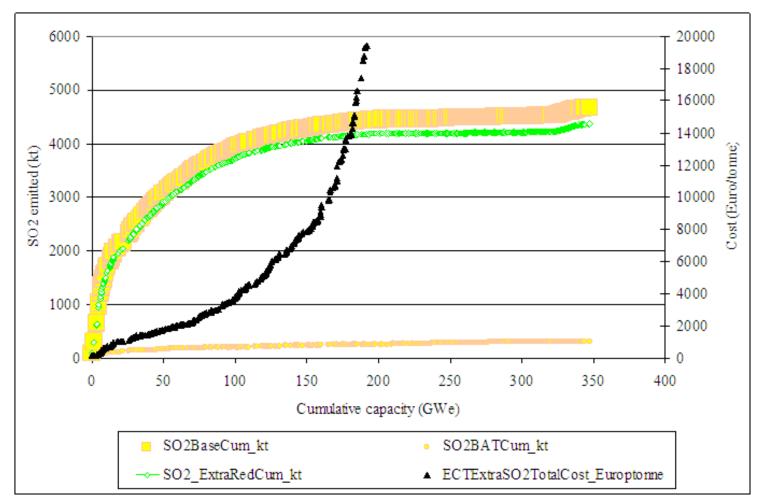
EU7: first 20 largest NOx emitters

	Cou	Plant	MWe		Base kt	ECT	Rem %	BAT Red kt	Emit post BAT kt	Euro /t
1	GBR	Drax	3960	Coal	58	Boi	50%	51	7	1838
2	POL	Belchatow	4340	Coal	40			38	2	3918
3	BGR	Maritsa II	1450	Coal	39			37	2	1247
4	ESP	Compostilla	1312	Coal	35			33	2	1391
5	ESP	Teruel	1050	Coal	31			30	2	1252
6	GBR	Aberthaw	1425	Coal	24			23	1	1791
7	PRT	Sines	1256	Coal	23	Boi	42%	21	2	1643
8	GBR	Ratcliffe	2000	Coal	23	Boi	50%	20	3	2170
9	GBR	West Burton	2000	Coal	23	Boi	42%	20	2	2464
10	BGR	Maritsa III	840	Coal	23			21	1	1247
11	ESP	La Robla	620	Coal	23			21	1	1007
12	GBR	Cottam	2008	Coal	22	Boi	50%	19	3	2227
13	GRC	Dimitrios	1570	Coal	22	Boi	50%	19	3	1801
14	ESP	Velilla	0	X	21					
15	GBR	Kingsnorth	1455	Coal	20	Boi	42%	18	2	1878
16	IRL	Moneypoint	915	Coal	20	Boi	50%	18	2	1175
17	GRC	Kardia	1200	Coal	20			19	1	2040
18	GBR	Ferrybridge	1470	Coal	20	Boi	50%	17	2	1912
19	ROM	Turceni	2310	Coal	20			19	1	3193
20	GBR	Longannet	2400	Coal	19	Boi	50%	17	2	2930



EU27 BATECT SO2 emission control costs

Stations ordered by increasing SO2 emission abatement cost

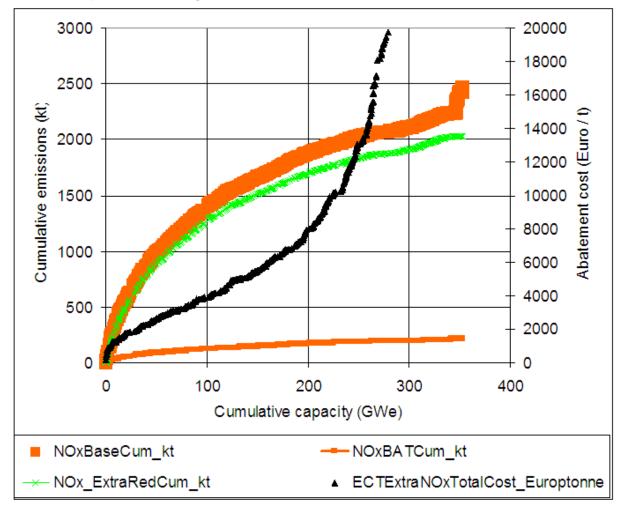






EU27 BATECT NOx emission control costs

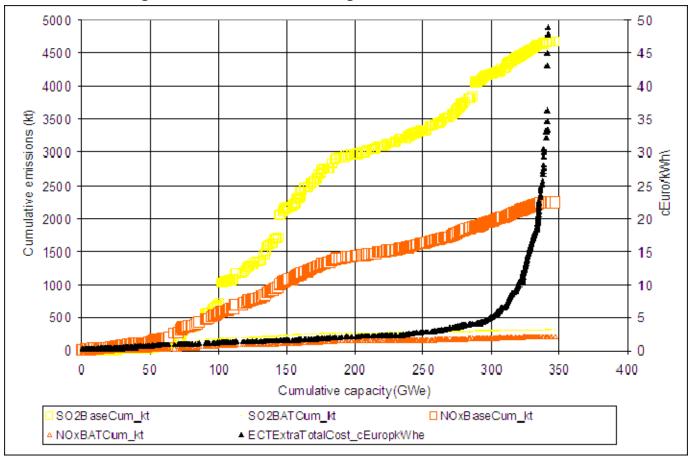
Stations ordered by increasing control cost





EU27 BATECT additional electricity costs

BATECT adds to generation costs because of ECT costs and efficiency loss. Current fossil generation cost in range 3-6 cEuro/kWh?

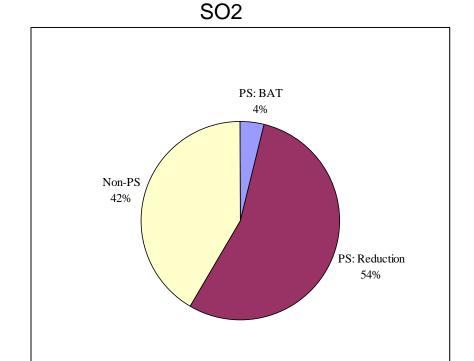


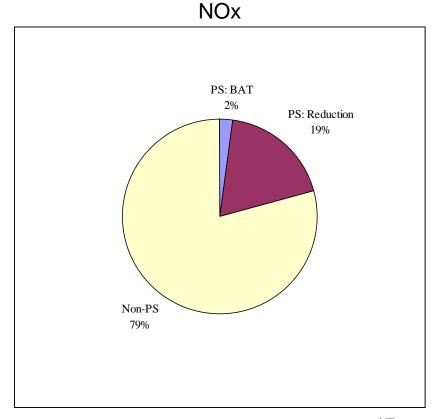




EU27 BATECT summary of emissions: 3000 power stations

Fractions of total EU27 emissions







EU27 BATECT summary of emissions and costs

200 power stations cover about 80% of all acid emissions from power stations

200 power s	SO2	NOx	SO2+NOx	CO2	
Fraction of EU27	Base	48%	15%		23%
	Reduction	45%	13%		-0.3%
Fraction of all power	82%	72%	79%	63%	

200	200 power stations			NOx	SO2+NOx	CO2 (Mt)
Emission	Base	kt	3920	1679	5599	856
	BAT	kt	261	173	434	845
	Reduction	kt	3659	1506	5165	-11
		%	93%	90%	92%	-1.3%
Cost	Total	MEuro/a	5364	3981	9345	
		Euro/tonne	1466	2643	1809	

3000 power stations cover about ~100% of all acid emissions from power stations

But abatement costs much larger

3000 power s	SO2	NOx	SO2+NOx	CO2	
Fraction of EU27	Base	58%	21%		35%
	Reduction	54%	19%		-0.4%
Fraction of all power	100%	100%	100%	99%	

3000	3000 power stations			NOx	SO2+NOx	CO2 (Mt)
Emission	Base	kt	4742	2337	7079	1341
	BAT	kt	307	250	557	1325
	Reduction	kt	4435	2087	6522	-16
		%	94%	89%	92%	-1.2%
Cost	Total	MEuro/a	11728	11300	23028	
		Euro/tonne	2644	5415	3531	



Conclusions: 1

- Total emissions dominated by a few power stations
- BATECT costs highly variable by size, fuel, etc.
- BATECT causes an increase in CO2
- Similar results for non-EU Europe, but greater emission reductions because less ECT currently applied and more coal used for generation.
- Mike Holland of EMRC will calculate health cost benefits of BATECT when I give him the data!



Conclusions: 2

Study does not account for energy scenario and electricity systems effects

Pressures to reduce conventional fossil generation:

- BATECT increases electricity costs, which enhances relative cost-effectiveness of energy efficiency and renewables
- Greenhouse gas emission control policies
- Decreased availability and increased price of gas



Spatial distribution will change at all scales; because of factors such as 'local' CHP and increased electricity exchange, e.g. with countries to the east of the EU.

Temporal distribution (diurnal, seasonal) will change because of change in demand patterns and increasing fraction of variable renewable electricity.