Best Available Technologies for Fossil Fuel Power Generation in the EU

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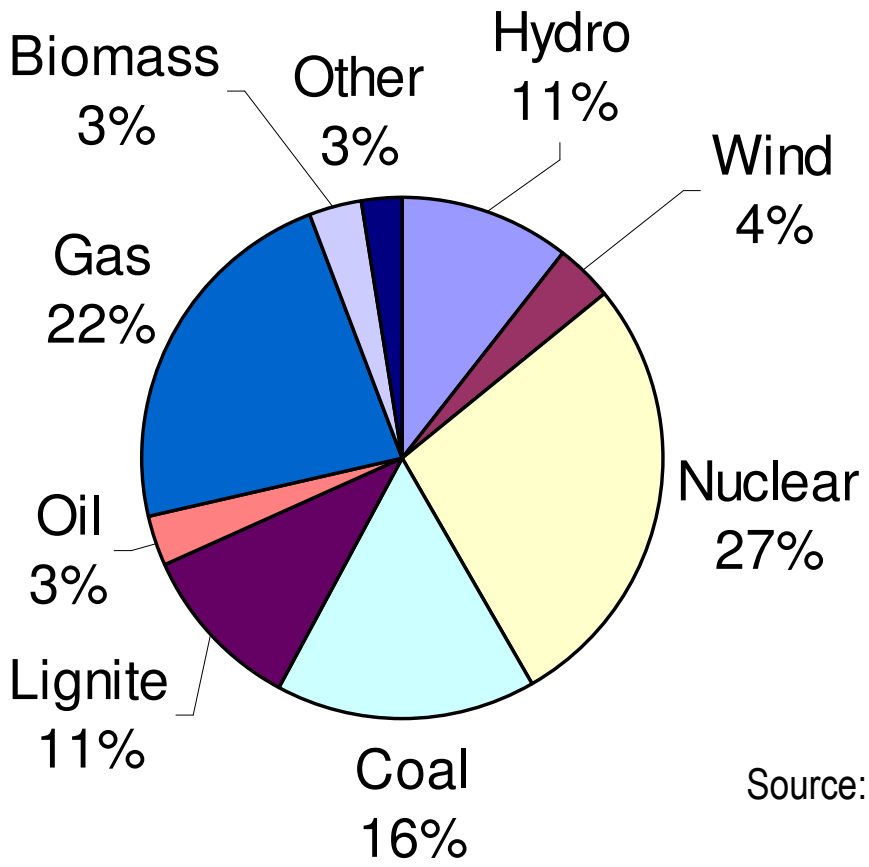
Presentation Outline

- A snapshot of the EU power sector
- Best Available Techniques for Large Combustion Plants – The EU IPPC BREF document
- Examples of state-of-the-art plants in the EU
- The next steps: The EU Strategic Energy Technology Plan (SET-Plan)

Power Generation in the EU (2008)

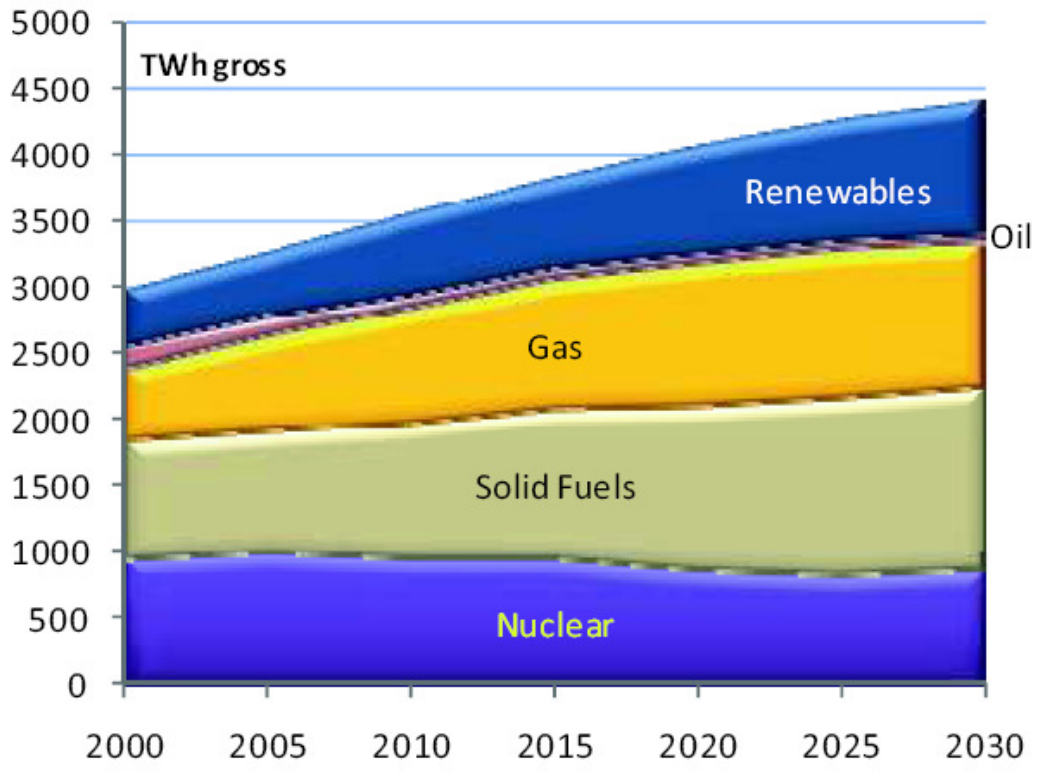


Source: EUROSTAT

In 2008, 3.4 million GWh were generated in the EU

52% was generated using fossil fuels

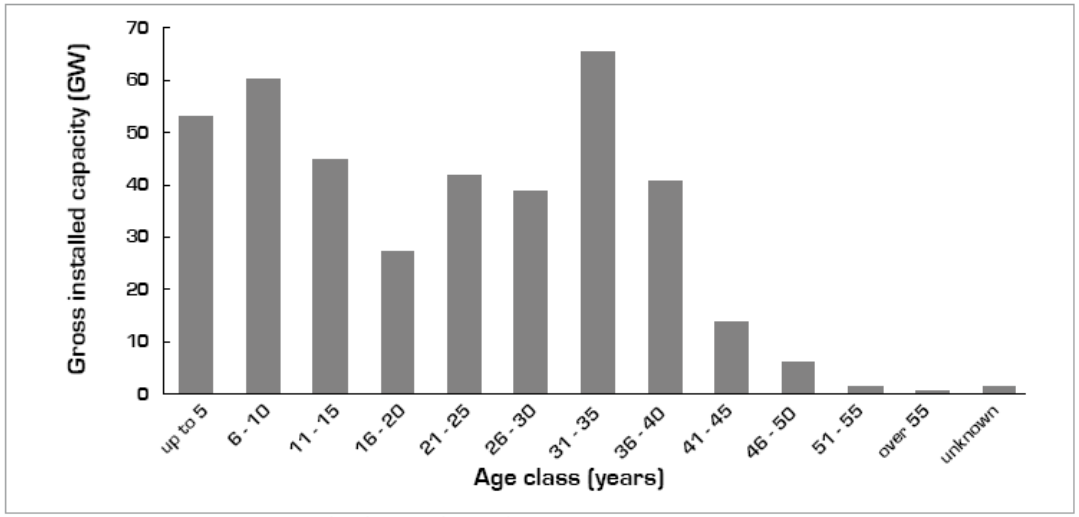
Power Generation Forecast



Source: PRIMES

According to PRIMES (2007), power generation in the EU will increase by 35% between 2005 and 2030. Fossil fuels will contribute by 57% (BAU)

Expansion of the Fossil Fuel Fleet



The EU fossil fuel power plant fleet is aged and needs to be renewed and expanded

CAPACITY EXPANSION (in GW) – New Energy Policy scenario

	2006-10		2011-15		2016-20		2005-2020	
Oil price	61$/bbl	100$/bbl	61$/bbl	100$/bbl	61$/bbl	100$/bbl	61$/bbl	100$/bbl
Total	*131.4*	*134.9*	*112.6*	*120.5*	*113.6*	*133.2*	*357.6*	*388.6*
Solids	8.5	8.9	33.1	35.7	6.1	14.2	47.7	58.8
Oil	2.9	3.5	1.8	2.4	0.9	1.1	5.5	7.0
Nuclear	0.7	0.7	3.9	3.9	2.8	5.1	7.4	9.7
Gas	60.5	60.3	16	16	13.1	17.4	89.5	93.8
RES	58	61.5	57.9	62.4	90.7	95.5	207.5	219.4

Source: PRIMES

The BREF

EUROPEAN COMMISSION

Integrated Pollution Prevention and Control

Reference Document on
Best Available Techniques for

Large Combustion Plants

July 2006

LCP BREF Overview

- Covers combustion installations with a rated thermal input over 50 MW
- Includes power generation and industries using conventional fuel, incl. co-combustion, but no waste incineration.
- Covers combustion units and related up- and down-stream activities.
- Does not cover processes that are an integrated part of a specific production process or use by-products as fuel.
- Developed in 2006 from more than 60 experts from the Member States, industry and NGOs.
- Will be updated in 2011.

LCP BREF: Contents

- General information about the industry and key environmental issues
- Common techniques for energy generation (combustion processes, steam cycles)
- Common processes & techniques to reduce emissions (PM, SOx, NOx, heavy metals, CO, halides, dioxins, GHGs, releases to water & soil, noise, etc.)
- Combustion techniques for:
  - Coal & lignite
  - Biomass and peat
  - Liquid fuels
  - Gaseous fuels
  - Co-combustion of waste and recovered fuel

Unloading, storage and handling of fuel and additives

PM	Spray systems, position of conveyors, equipment for min. height fuel drop, etc.
Water contamination	Drainage, containment of liquid fuel systems, proper position of pipelines, etc.
Fire prevention	Automatic system surveying
Fugitive emissions	Leak detection systems
Efficient use of natural resources	Energy recovery w/ expansion turbines, gas preheating
HS w.r.t. NH_3	Optimal construction of reservoirs, use of water solutions

Thermal Efficiency

Fuel	Technology	Efficiency (%)
Coal	PC	43-47
	FBC	>41
	PFBC	>42
Lignite	PC	42-45
	FBC	>40
	PFBC	>42
Biomass	Grate-firing	~20
	Spreader-stroker	>23
	FBC	>28-30
Peat	FBC	>28-30
All Solid Fuels	Cogeneration	75-90

Efficiency can be improved by at least 3% with the use of BATs

Thermal Efficiency

Technology	Electrical Efficiency (%)	
	New plants	Old plants
Gas turbine	36-40	32-35
Gas engine	38-45	
Gas engine w/HRSG in CHP mode	>38	>35
Gas-fired boiler	40-42	38-40
CCGT	54-58	50-54
CCGT w/o HRSG in CHP mode	<38	<35
CCGT w/HRSG in CHP mode	<40	<35

Fuel utilisation in CHP mode is 75-85%

BATs for PM Emissions

Capacity (MW_{th})	Dust emission level (mg/Nm^3)						BAT to reach these levels
	Coal and lignite		Biomass and peat		Liquid fuels for boilers		
	New plants	Existing plants	New plants	Existing plants	New plants	Existing plants	
50 – 100	5 – 20*	5 – 30*	5 – 20	5 – 30	5 – 20*	5 – 30*	ESP or FF
100 – 300	5 – 20*	5 – 25*	5 – 20	5 – 20	5 – 20*	5 – 25*	ESP or FF in combination FGD (wet, sd or dsi) for PC ESP or FF for FBC
>300	5 – 10*	5 – 20*	5 – 20	5 – 20	5 – 10*	5 – 20*	

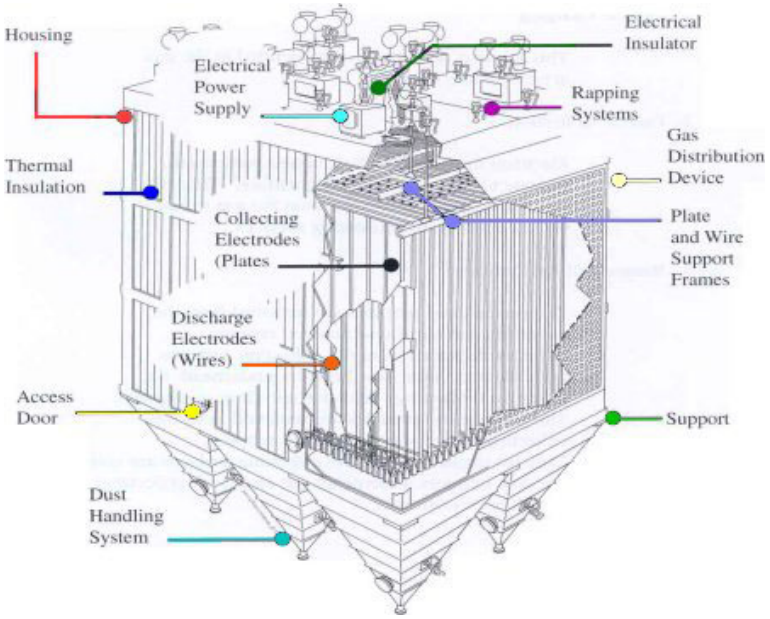
Notes:
ESP: Electrostatic precipitator) **FF:** Fabric filter **FGD(wet):** Wet flue-gas desulphurisation
FBC: Fluidised bed combustion) **sd:** semi dry **dsi:** dry sorbent injection
* Some split views appeared in these values and are reported in Sections 4.5.6 and 6.5.3.2 of the main document.

Overall, ESPs and FFs can achieve very low PM emissions, less than 5 mg/Nm^3

BATs for Heavy Metal Emissions

- BAT is the application of high performance dedusting devices, such as ESPs and FFs.

- ESPs/FFs in combination with FGD techniques can achieve an average removal rate for Hg of 75%, increased to 90% with the additional use of SCR.



Source: The Neundorfer KnowledgeBase

BATs for SOx Emissions

Capacity (MW_{th})	SO_2 emission level (mg/Nm^3)						BAT to reach these levels
	Coal and lignite		Peat		Liquid fuels for boilers		
	New plants	Existing plants	New plants	Existing plants	New plants	Existing plants	
50 – 100	200 – 400* 150 – 400* (FBC)	200 – 400* 150 – 400* (FBC)	200 – 300	200 – 300	100 – 350*	100 – 350*	Low sulphur fuel or/and FGD (dsi) or FGD (sds) or FGD (wet) (depending on the plant size). Seawater scrubbing. Combined techniques for the reduction of NO_x and SO_2. Limestone injection (FBC).
100 – 300	100 – 200	100 – 250*	200 – 300 150 – 250 (FBC)	200 – 300 150 -300 (FBC)	100 – 200*	100 – 250*	
>300	20 – 150* 100 – 200 (CFBC/ PFBC)	20 – 200* 100 – 200* (CFBC/ PFBC)	50 – 150 50 – 200 (FBC)	50 – 200	50 – 150*	50 – 200*	

Notes:

FBC: Fluidised bed combustion

CFBC: Circulating fluidised bed combustion

PFBC: Pressurised fluidised bed combustion

FGD(wet): Wet flue-gas desulphurisation

FGD(sds): Flue-gas desulphurisation by using a spray dryer

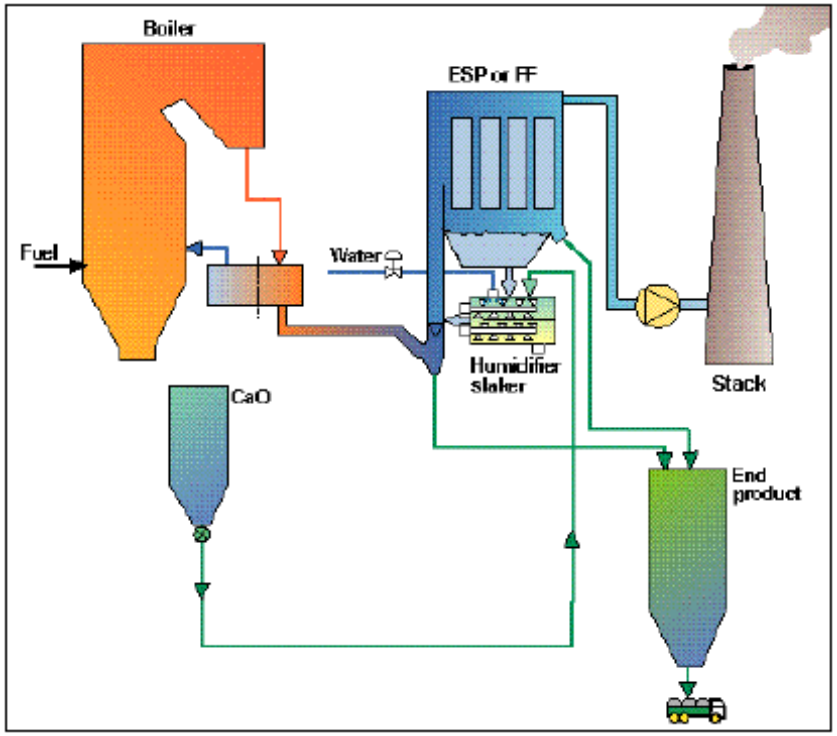
FGD(dsi): Flue-gas desulphurisation by dry sorbent injection

* Some split views appeared in these values and are reported in Sections 4.5.8 and 6.5.3.3 of the main document.

BATs for SOx Emissions

- Low sulphur fuel (<100 MW)
- Dry FGD (reduction 85-92%) (<300 MW)
- Wet FGD (reduction 92-98%) (>100 MW)

Modified dry FGD



Source: BREF

BATs for NOx Emissions: Coal

Capacity (MW_{th})	Combustion technique	NO_X emission level associated with BAT (mg/Nm^3)			BAT options to reach these levels
		New plants	Existing plants	Fuel	
50 – 100	Grate-firing	200 – 300*	200 – 300*	Coal and lignite	Pm and/or SNCR
	PC	90 – 300*	90 – 300*	Coal	Combination of Pm and SNCR or SCR
	CFBC and PFBC	200 – 300	200 – 300	Coal and lignite	Combination of Pm
	PC	200 – 450	200 – 450*	Lignite	
100 – 300	PC	90* – 200	90 – 200*	Coal	Combination of Pm in combination with SCR or combined techniques
	PC	100 – 200	100 – 200*	Lignite	Combination of Pm
	BFBC, CFBC and PFBC	100 – 200	100 – 200*	Coal and Lignite	Combination of Pm together with SNCR
>300	PC	90 – 150	90 – 200	Coal	Combination of Pm in combination with SCR or combined techniques
	PC	50 – 200*	50 – 200*	Lignite	Combination of Pm
	BFBC,CFBC and PFBC	50 – 150	50 – 200	Coal and Lignite	Combination of Pm

Notes:

PC: Pulverised combustion
CFBC: Circulating fluidised bed combustion
Pm: Primary measures to reduce NO_x
SNCR: Selective non catalytic reduction of NO_x
BFBC: Bubbling fluidised bed combustion
PFBC: Pressurised fluidised bed combustion
SCR: Selective catalytic reduction of NO_x

The use of anthracite hard coal may lead to higher emission levels of NO_X because of the high combustion temperatures

* Some split views appeared in these values and are reported in Section 4.5.9 of the main document.

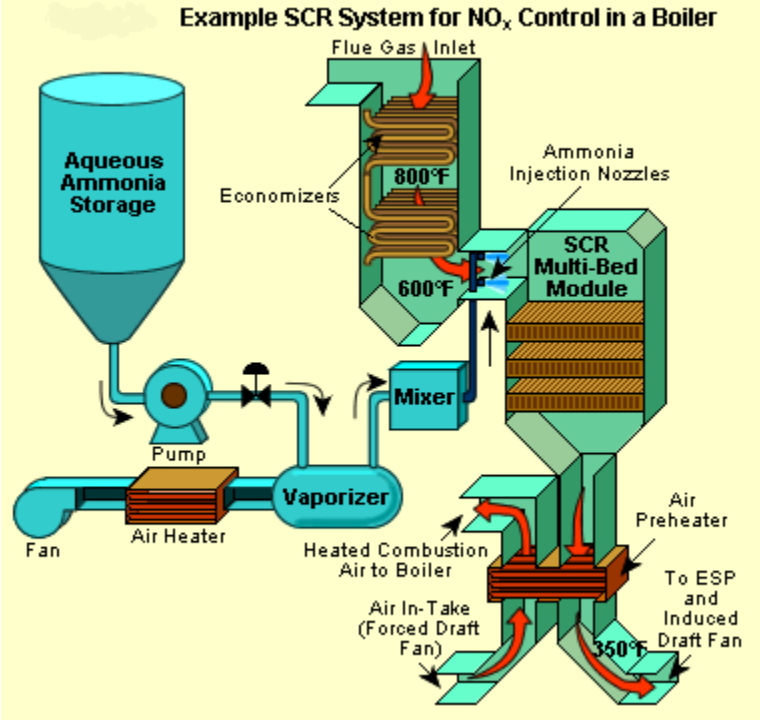
BATs for NOx Emissions: Gas

Plant type	Emission level associated with BAT (mg/Nm^3)		O_2 level (%)	BAT options to reach these levels
	NO_x	CO		
Gas turbines				
New gas turbines	20 – 50	5 – 100	15	Dry low NO_x premix burners or SCR
DLN for existing gas turbines	20 – 75	5 – 100	15	Dry low NO_x premix burners as retrofitting packages if available
Existing gas turbines	50 – 90*	30 – 100	15	Water and steam injection or SCR
Gas engines				
New gas engines	20 – 75*	30 – 100*	15	Lean-burn concept or SCR and oxidation catalyst for CO
New gas engine with HRSG in CHP mode	20 – 75*	30 – 100*	15	Lean-burn concept or SCR and oxidation catalyst for CO
Existing gas engines	20 – 100*	30 – 100	15	Low NO_x tuned
Gas-fired boilers				
New gas-fired boilers	50 – 100*	30 – 100	3	Low NO_x burners or SCR or SNCR
Existing gas-fired boile	50 – 100*	30 – 100	3	
CCGT				
New CCGT without supplementary firing (HRSG)	20 – 50	5 – 100	15	Dry low NO_x premix burners or SCR
Existing CCGT without supplementary firing (HRSG)	20 – 90*	5 – 100	15	Dry low NO_x premix burners or water and steam injection or SCR
New CCGT with supplementary firing	20 – 50	30 – 100	Plant spec.	Dry low NO_x premix burners and low NO_x burners for the boiler part or SCR or SNCR
Existing CCGT with supplementary firing	20 – 90*	30 – 100	Plant spec.	Dry low NO_x premix burners or water and steam injection and low NO_x burners for the boiler part or SCR or SNCR

SCR: Selective catalytic reduction of NO_x **SNCR:** Selective non catalytic reduction of NO_x
DLN: dry low NO_X **HRSG:** heat recovery steam generator **CHP:** Cogeneration
CCGT: combined cycle gas turbine
* Some split views appeared on these values and are reported in Section 7.5.4 of the main document..

BATs for NOx Emissions

- **Pulverised fuel:** Primary (Low NOx burners, recirculation, air staging, etc.) and secondary measures (SCR) can reduce NOx by 80-95%



Source: DoE

- **Gas Turbines:** DLN burners, SCR

State-of-the-art Power Plants in the EU

Nordjyllandsvaerket 3 (DK)

- The most efficient plant in the world (47% LHV)
- International steam coals
- Net power output: 384 MW
- Steam conditions: 29 MPa/ 582°C/ 580°C/ 580°C
- Start of operation: Oct. 1998
- Low NOx burners, air staging, high-dust SCR, ESP, FGD
- NOx: 146 mg/m^3 – SO_2: 13 mg/m^3 – PM: 18 mg/m^3
- CAPEX: €1700/kW

Source: co2.no

Niederaussem K (DE)

- Example of efficient and clean lignite plant (43.2% LHV)
- High moisture lignite (50-60%)
- Net power output: 965 MW
- Steam conditions: 27.5 MPa /580°C / 600°C
- Start of operation: 2002
- Tangestial wall firing, low NOx burners, overfire air, wet FGD, ESP
- NOx: <200 mg/m^3 – SO2: <200 mg/m^3 – PM: < 50 mg/m^3
- CAPEX: € 1250/kW

Source: RWE

Lagisza (PL)

- First supercritical CFB (43.3% LHV)
- Polish bituminous coal
- Net power output: 439 MW
- Steam conditions: 27.5 MPa /560°C
- Start of operation: 2009
- Low combustion temperature, staged combustion, FGD, ESP (SNCR)
- NOx: <200 mg/m^3 – SO2: <200 mg/m^3 – PM: < 50 mg/m^3
- CAPEX: €326/kW (power island only)

Source: FW

Puertollano (ES)

- IGCC (<43% LHV)
- Sub-bituminous high ash coal mixed with petroleum coke
- Net power output: 298 MW
- Gasification conditions: 25 bar / 1200-1600°C
- Start of operation: 1997
- MDEA/Claus, control of flame temperature by mixing with N_2
- NOx: 150 mg/m^3 – SO_2: 25 mg/m^3 – PM: 7.5 mg/m^3
- CAPEX: €3500/kW (excl. IDC)

Source: ELCOGAS

Enfield (UK)

- NGCC (58% LHV – 52% @ 40% CF)
- Natural gas
- Net power output: 372.5 MW
- Start of operation: 2002
- Low NOx burners
- NOx: <25 ppm
- CAPEX: €1100/kW

Source: IEA CCC

Schwarze Pumpe (DE)

A glance into the future!

- Pilot oxyfuel-combustion plant
- Pulverised dry lignite and bituminous coal
- Capacity: 30 $MW_{thermal}$
- CO_2 capture capacity: 75,000 t/y
- Start of operation: 2008

Source: ALSTOM

The Future of Energy Technology Development in the EU

The European Strategic Energy Technology Plan

For meeting the EU energy challenge,

Europe's INNOVATION must adapt

STRATEGIC ENERGY TECHNOLOGY PLAN

- Accelerate energy technology innovation
- Strategic planning & joint implementation: coordinated efforts at EU level – supported by an Information System (SETIS) led by the JRC

CCS is among the EU energy technology priorities

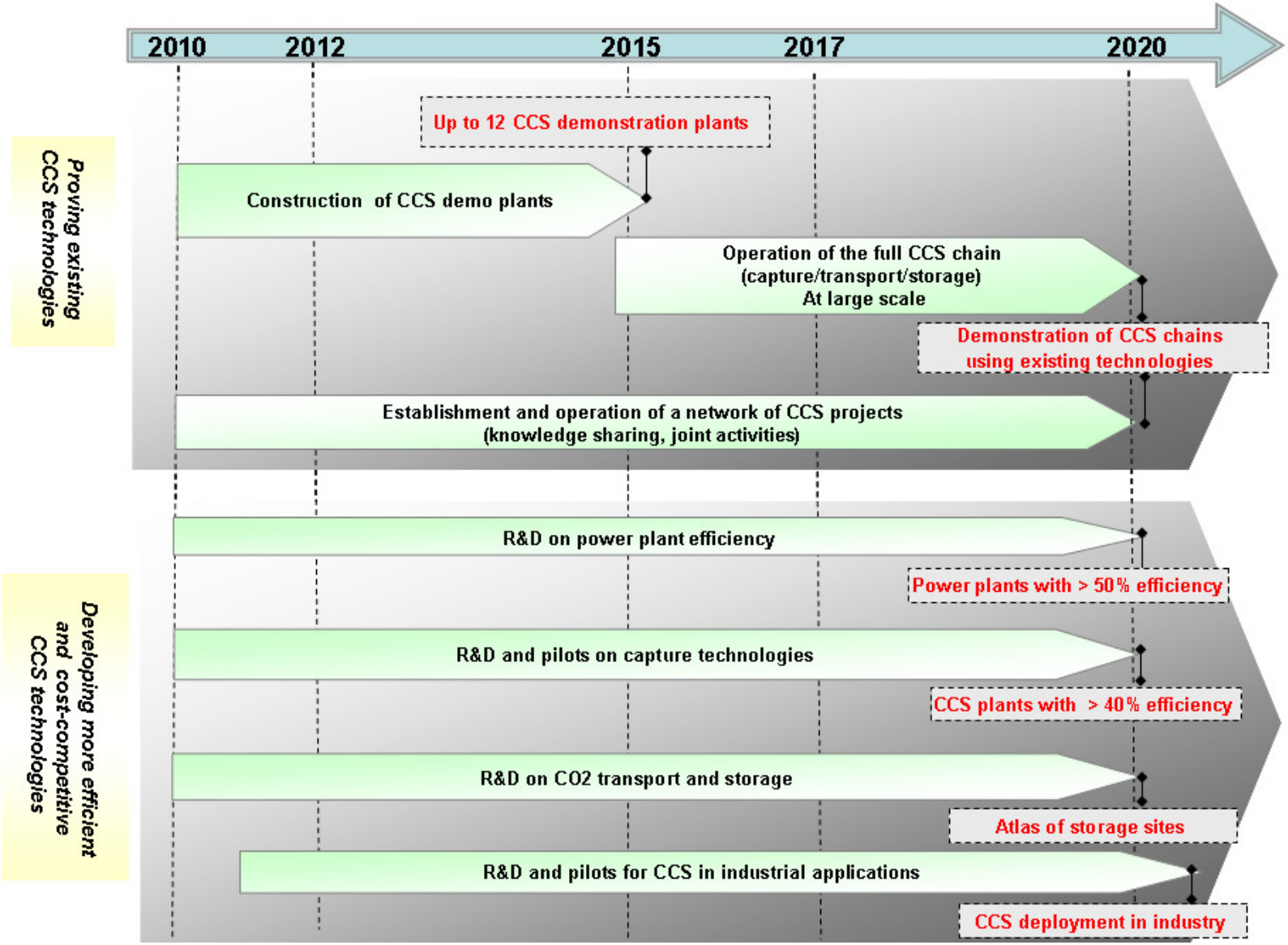
Aim: *reach cost competitiveness of CCS within a carbon pricing environment by 2020-2025*

What: reduce cost, increase efficiencies, test CO_2 storage, promote public awareness

How: "up to 12 demonstration plants" + R&D

Cost: 13 billion €

The CCS Roadmap



The CCS Demonstration Programme

Hatfield (UK)
Pre-combustion

Jaenschwalde (D)
Oxyfuel & Post-comb.

Rotterdam (NL)
Post-combustion

Belchatow (PL)
Post-combustion

Compostilla (ES)
Oxyfuel combustion

Porto-Tolle (IT)
Post-combustion

6 projects – 1 billion Euro

European Energy Programme for Recovery

SETIS: Energy Technology Information Portal

Robust, consented technology-neutral planning tools at EU level

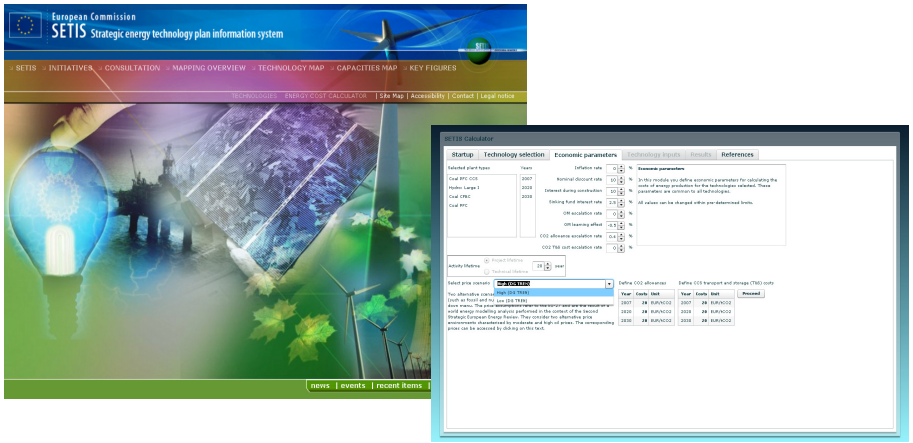
Technology Maps:

- Potential market penetration – 2020 / 2050
- Key barriers and R&D needs
- Reference values for technology performance
- Impact on energy and climate change goals

SETIS Website

http//:setis.ec.europa.eu

- On-line tools
- Depository of references



On-line calculator

Thank you for your attention

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