

UN-ECE
November 17-18, 2003
Geneva, Switzerland

Air Pollution Control

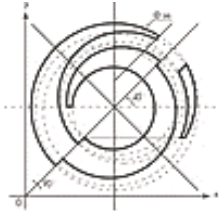
Regulatory & Technology

Development

Alain Bill

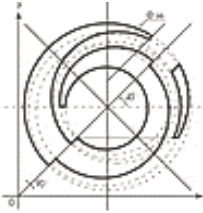
ALSTOM

UNECE Ad Hoc Group of
Experts on Coal in
Sustainable Development
17 November 2003



Agenda

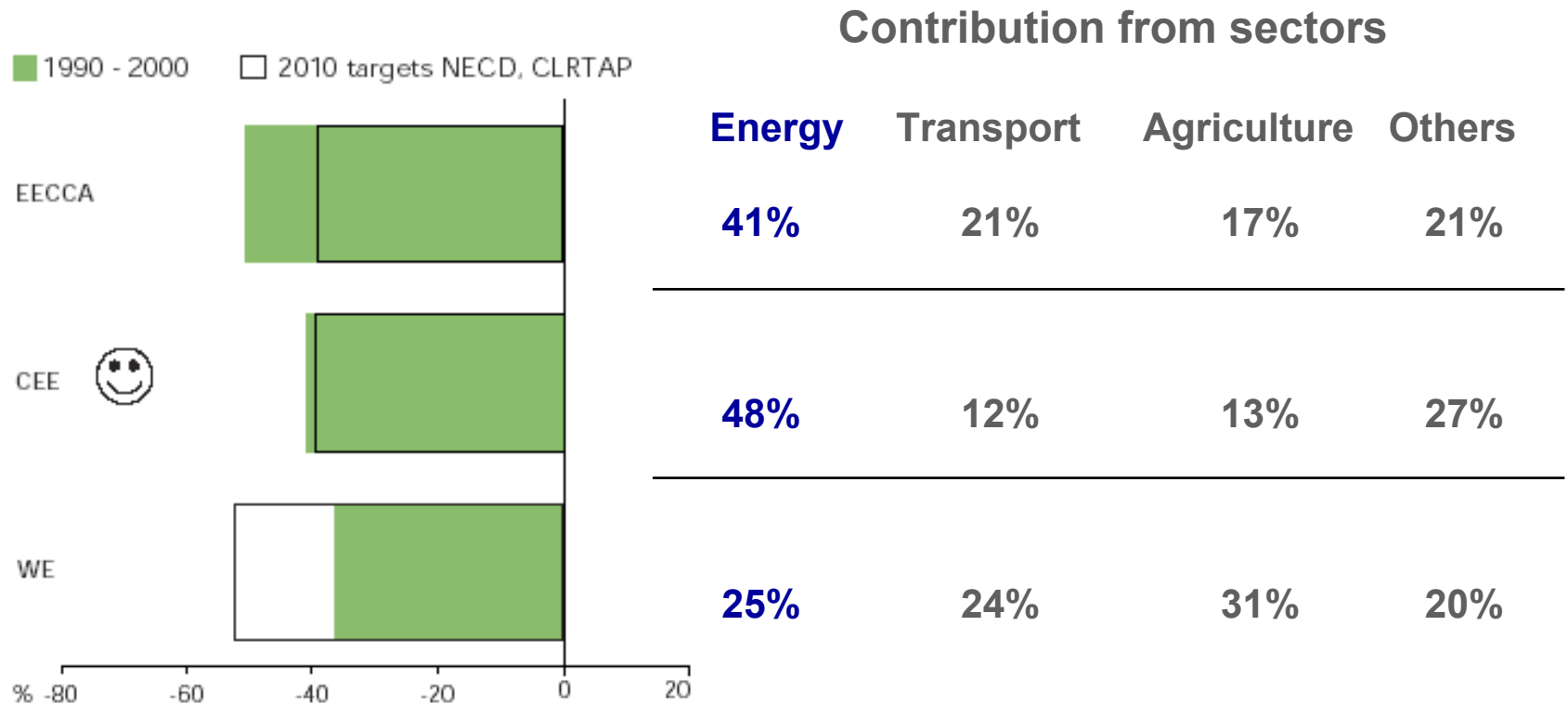
- Emissions trend
- Future trends in regulations and technologies
- Technological options
 - Gaseous emissions
 - Particulate emission



The Current Status

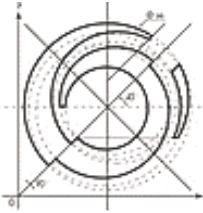


Change in emissions of acidifying substances for 1990-2000 [to EU NEC and UNECE CLRTAP targets for 2010]



EECCA: Eastern Europe, Caucasus and Central Asia
 CEE: Central and Eastern Europe
 WE: Western Europe

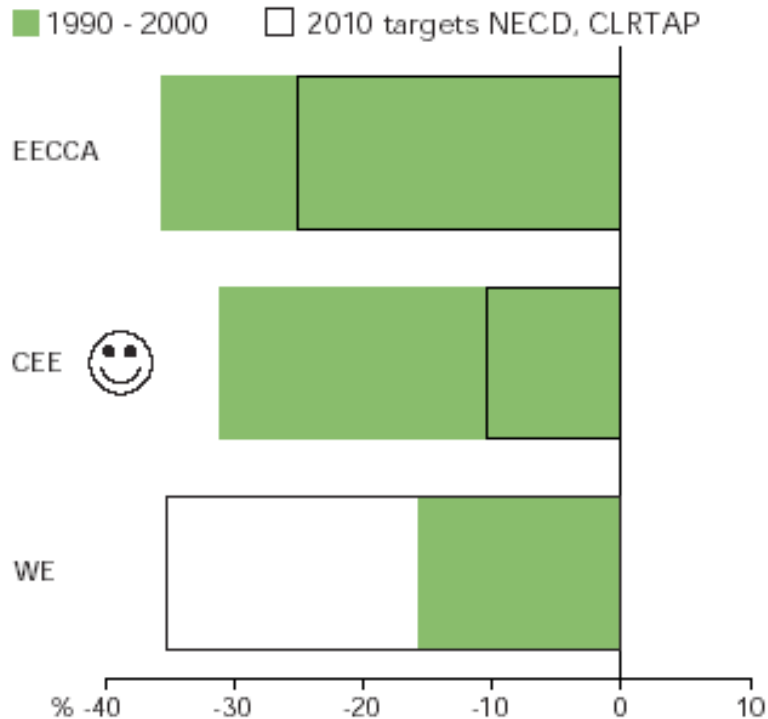
Source: EEA 2002



The Current Status



Change in emissions of eutrophying substances for 1990-2000 [to EU NEC and UNECE CLRTAP targets for 2010]

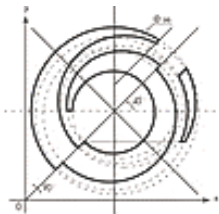


Contribution from sectors

Energy	Transport	Agriculture	Others
41%	16%	21%	32%
22%	33%	20%	25%
13%	47%	24%	16%

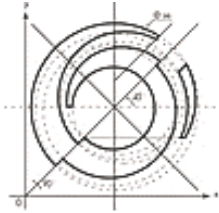
EECCA: Eastern Europe, Caucasus and Central Asia
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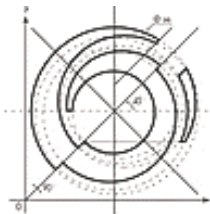
The Current Status

- Although emissions of acidifying and nitrogen compounds have fallen since 1990, substantial further reductions are believed necessary to reach the 2010 Gothenburg Protocol and NEC directive targets
- Many “hot-spot” areas remain at risk especially in central Europe



Agenda

- Emissions trend
- Future trends in regulations and technologies
- Technological options
 - Gaseous emissions
 - Particulate emission



Impetus for New Pollution Control Standards for Power Plants



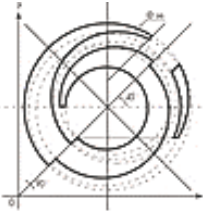
- Reducing power plant emissions will reduce deposition of pollutants and direct exposure to ambient concentration of pollutants

Deposition issues

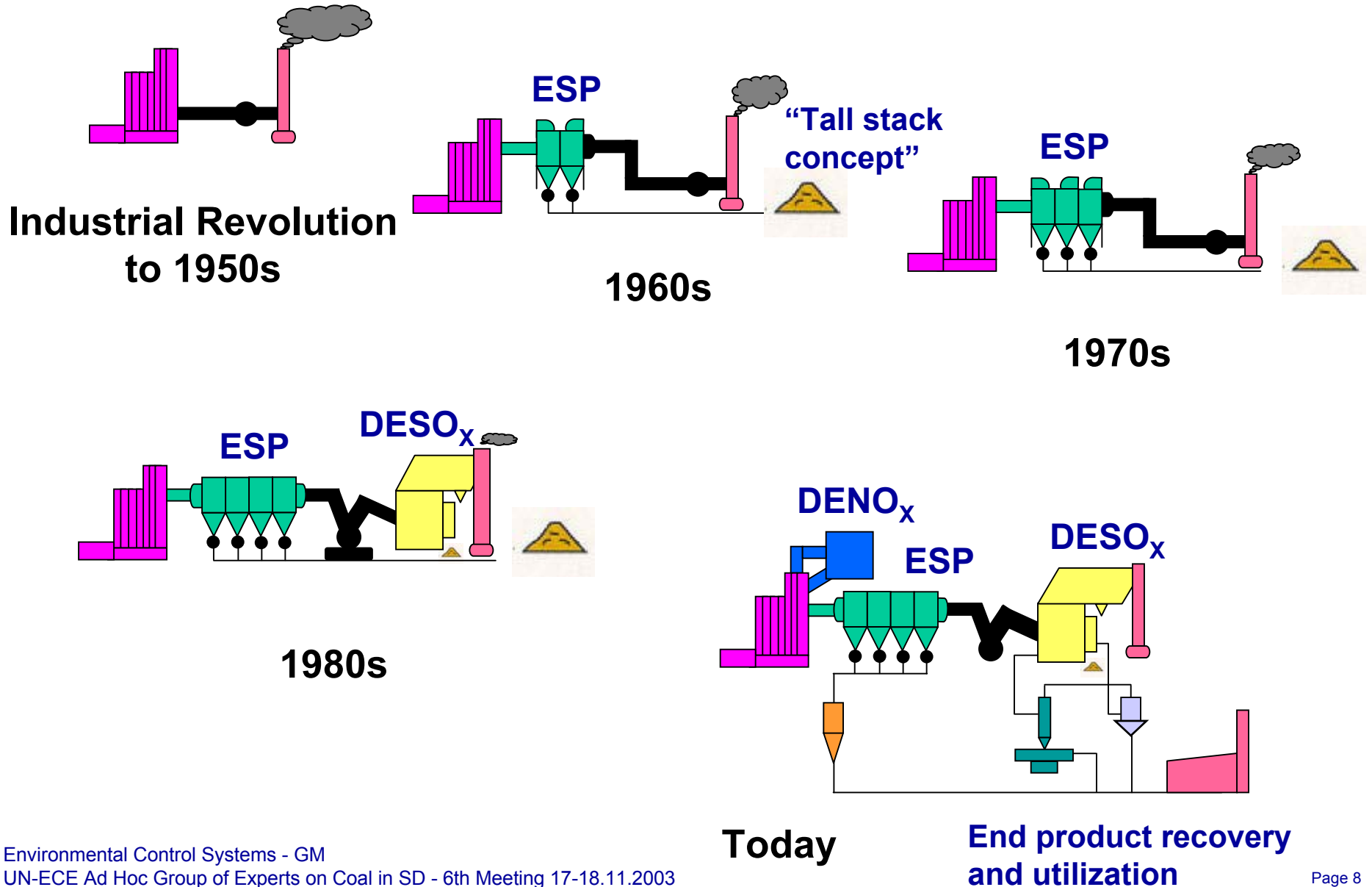
- acidification of soils and freshwater
- eutrophication of terrestrial, freshwater and marine ecosystems
- material damages

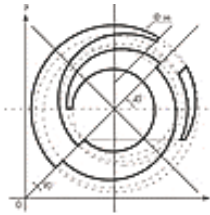
Air quality

- human health effects resulting from:
 - ground-level ozone
 - particulate matter
 - other pollutants
- adverse effects on vegetation and crops



Perception of Emissions' Value

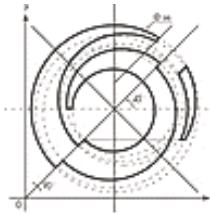




Impetus for New Pollution Control Standards The Policy Framework



- European Community legislation and strategies:
 - Integrated Pollution Prevention and Control directive (IPPC - 1996)^{*)} - [into force]
 - Waste Incineration directive (WI - 2000) - [into force]
 - National Emission Ceilings directive (NEC - 2001)^{*)} - [into force]
 - Large Combustion Plant directive (LCP - 2001)^{*)} - [2008]
 - Greenhouse Gas Emission Allowance Trading directive (ET - 2003)^{*)} - [2005]
 - “Polluter Pays” approach to liability^{*)} - [open, submitted to the Council of Ministers]

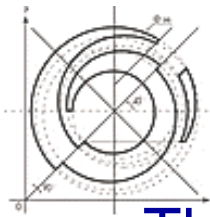


IPCC Directive



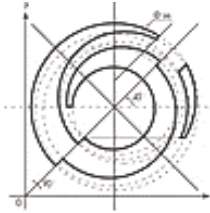
- The Directive introduces the concept of an integrated environmental licensing system which will apply to a range of industrial processes including combustion installations greater than 50 MWth
- The IPPC Directive sets:
 - procedures for applying for, issuing and amending operating permits for industrial installations (including coal-fired plants)
 - the minimum requirements to be included in any such permit - compliance with basic obligations, emission limit values for pollutants, monitoring discharges, minimisation of long-distance or transboundary pollution

The emission limit values are set either by the Council or taken from a series of Directives on pollution

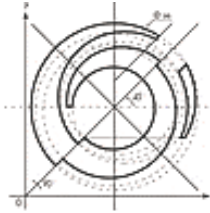


IPPC Directive

- The air pollutants included in the IPPC Directive are:
 - SO₂ and other sulphur compounds
 - NO_x and other nitrogen compounds
 - carbon monoxide
 - VOC
 - metals and their compounds
 - dust (particulate matter)
 - asbestos (suspended particulate, fibres)
 - chlorine and its compounds
 - fluorine and its compounds
 - arsenic and its compound;
 - cyanides
 - substances and preparations which have been proved to possess carcinogenic or mutagenic properties or properties which may affect reproduction via the air
 - polychlorinated dibenzodioxins and polychlorinated dibenzofurans



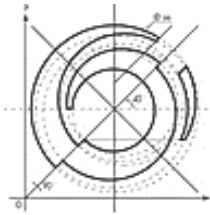
- The regime was applied to all new plants and existing plants undergoing modification and is to be extended to all existing plants by 2007 at the latest
- Member States were to introduce their own schedule to meet this deadline. Competent authorities in each country must ensure that all appropriate measures are taken, including BAT
- The BAT for each industry is not prescribed but is assessed by the competent authority based on site- and plant-specific factors
- Permits are issued which apply to emission limits for releases to air and water and include measures regarding the minimisation of waste production



IPPC Directive



- Annex IV of the IPPC Directive contains considerations to be taken into account when determining BAT
- Also, the EC organises exchange of information between experts from the EU Member States, industry and environmental organisations
- BAT reference documents (BREFs) are produced which must be taken into account when authorities of Member States determine conditions for IPPC permits



2nd Draft Reference Document BAT for Large Combustion Plants



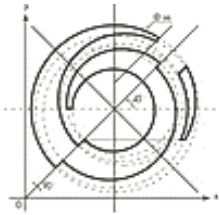
- This 3 years revision will establish a new Reference Document on Best Available Techniques by the end of 2003 in which it will list the technologies which ensure a high level of protection for the environment as a whole



EUROPEAN COMMISSION
DIRECTORATE-GENERAL JRC
JOINT RESEARCH CENTRE
Institute for Prospective Technological Studies (Seville)
Technologies for Sustainable Development
European IPPC Bureau

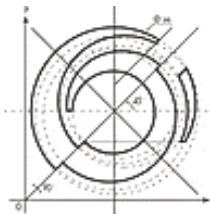
Integrated Pollution Prevention and Control (IPPC)
Draft Reference Document on Best Available Techniques
for Large Combustion Plants
Draft March 2003

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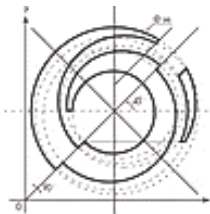
The National Emissions Ceilings Directive

- The NEC directive sets limits for each member state for SO₂, NO_x VOC and ammonia
- The NEC directive sets more stringent limits of SO₂ and NO_x emissions for many countries than those specified in the Gothenburg Protocol
- The NEC directive provides binding national ceilings for 2010 along with EU-wide aggregate, but non-binding, limits for SO₂, NO_x and VOCs
- Aggregate emissions of these pollutants are to be reduced between 1990 and 2010 as follows:
 - SO₂ (-74%)
 - NO_x (-45%)
 - VOC (-44%)
 - NH₃ (-18%)



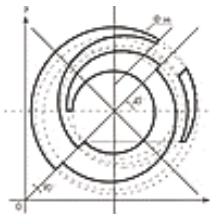
The Large Combustion Plant Directive **ALSTOM**

- The LCP directive sets emission limit values from 2008 according to the fuel used for plants larger than 50 MWth
- The directive has 3 plant categories:
 - existing plants (licensed before 1st of July 1987)
 - new plants (licensed after 1st of July 1987 but before 27th November 2002 (and operational before 27th November 2003))
 - new-new plants (licensed after 27th November 2003)
- Member countries may devise a national emission reduction plan (NERP) and set their own legislation or requirements as long as the plan ensures the same emissions total that applying the ELVs for individual plants would have done (to be communicated to the Commission no later than 27th November 2003)



The Large Combustion Plant Directive **ALSTOM**

- The Commission will evaluate (within 6 months) whether or not the plan meets the requirements
- There are also a few derogation (plants ≥ 400 MWth operating less than 2000 hours per year (until 2015) + for some power plants in Spain) and opt-out option for utilities which decide not to operate the plant for more than 20,000 hours starting from 1st January 2008 and ending no later than 31st December 2015
- It seems to be a common opinion that the LCP directive will lead to the closure of many coal-fired and some older oil-fired power plants



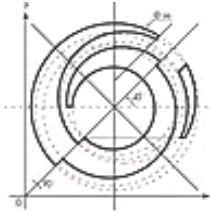
Options & ELVs to operate a 500 MWth coal-power plant under the EU LCPD **ALSTOM**

Currently existing plan licensed before 1 July 1987? <i>(known as “existing” plant)</i>	Licensed after 1 July 1987 and in operation before 27 Nov 2003? <i>(known as “old new” plant)</i>	Licensed after 1 July 1987 and in operation after 27 Nov 2003? <i>(known as “new new” plant)</i>
Member States (MS) may choose either:	No choice for MS	No choice for MS

Emission Limit Values (ELV) as per Annexes A of LCPD	ELV as per Annexes A of LCPD	ELV as per Annexes B of LCPD
SO₂ 400 mg/Nm ³ If limited to 2000 hrs pa from 2008- 2015 or 1500 hrs pa from 2016 (5yr rolling average) 800 mg/Nm ³	SO₂ 400 mg/Nm ³ If limited to 2000 hrs pa from 2008-2015 or 1500 hrs pa from 2016 (5yr rolling average) 800 mg/Nm ³	SO₂ 200 mg/ Nm ³
NO_x 500 mg/Nm ³ to 2015 200 mg/Nm ³ from 2016 If limited to 2000 hrs pa from 2008-2015 600 mg/Nm ³ If limited to 1500 hrs pa from 2016 450 mg/Nm ³ If operated on low volatile solid fuel 1200 mg/Nm ³ until 2018 200 mg/Nm ³ from 2018	NO_x 500 mg/Nm ³ to 2015 200 mg/Nm ³ from 2016 If limited to 2000 hrs pa from 2008-2015 600 mg/Nm ³ If limited to 1500 hrs pa from 2016 450 mg/Nm ³ If operated on low volatile solid fuel 1200 mg/Nm ³ until 2018 200 mg/Nm ³ from 2018	NO_x 200 mg/Nm ³
Dust 50mg/Nm ³	Dust 50mg/Nm ³	Dust 30mg/Nm ³

or,
National Emission Reduction Plan (NERP)
 or,
**Operators may opt out of ELV and NERP by:
 Declaring by 30 June 2004 not to operate the plant for more than 20,000 hrs between 1 Jan 2008 and 31 Dec 2015.**

18.11.2003

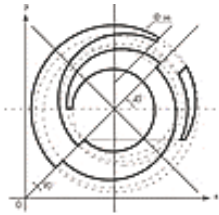


Impetus for New Pollution Control Standards The Policy Framework



- The EC also launched the Clean Air for Europe (CAFÉ) program in May 2001

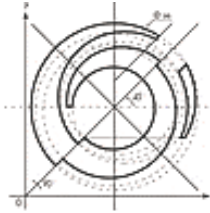
This 3 year program will establish a long-term, integrated strategy by 2004 in which it will provide the framework within which new air quality standards and national emissions ceilings will be set



Impetus for New Pollution Control Standards Additional Policy Elements

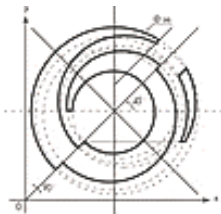


- The United Nations Economic Commission for Europe (UNECE) Convention on Long-Range Transboundary Air Pollution (CLRTAP)
- The Convention has been extended by 8 protocols:
 - Oslo Protocol on Further Reduction of Sulfur Emissions (1994) - [in force]
 - Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (1999) - [open]
 - ...

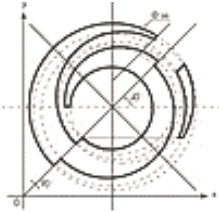


Agenda

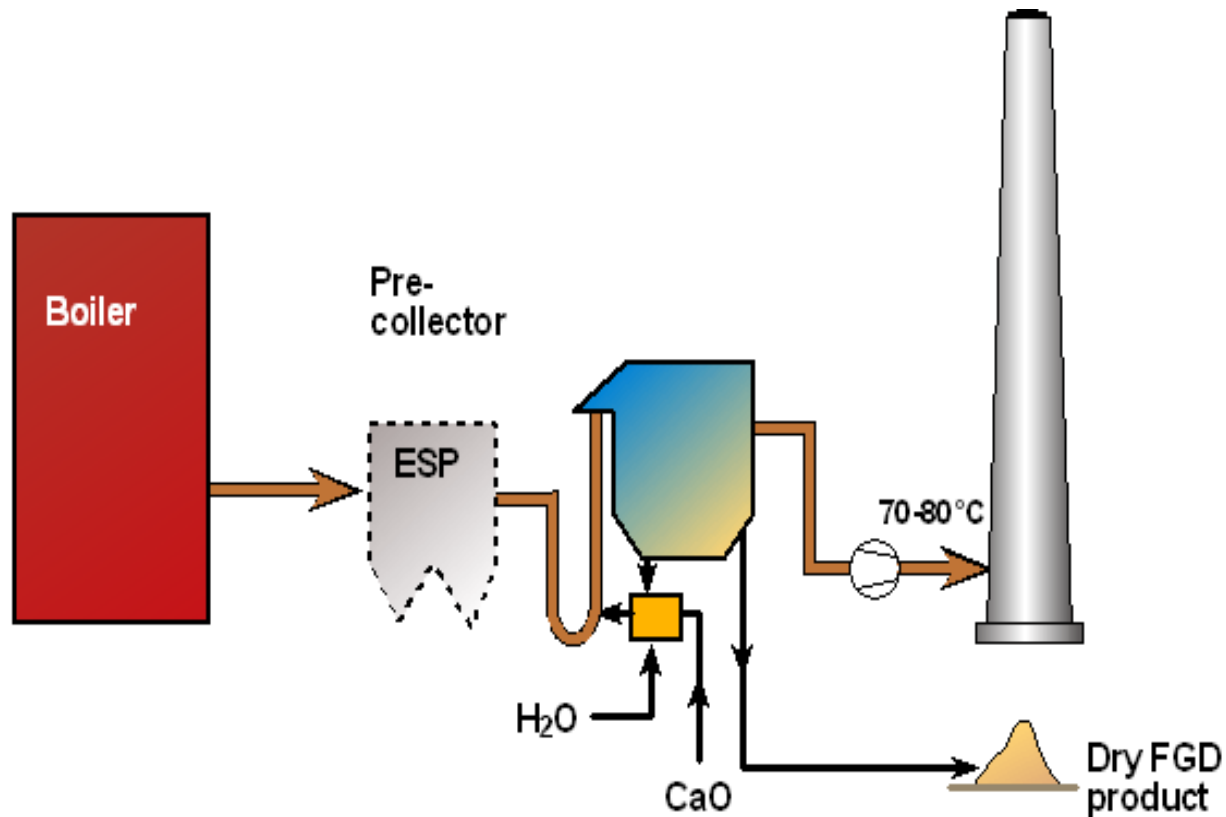
- Emissions trend
- Future trends in regulations and technologies
- Technological options
 - Gaseous emissions: Sulfur Oxides
 - Particulate emission

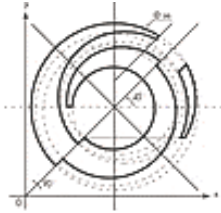


FGD Process	Features	Reagent	Byproduct
Seawater FGD	SO ₂ absorption with seawater in scrubber. Seawater treatment	None	None
Dry FGD	Lime injection in flue gas stream. Dry by-product removed by filter	CaO or Ca(OH) ₂	Ca SO ₃ • 1/2 H ₂ O
Wet Limestone	Limestone slurry sprayed in absorber tower. Aeration and de-watering + Flowpac	Ca CO ₃	CaSO ₄ • 2 H ₂ O



Dry/Semi-dry FGD Process Description





Absorption Reactions

- **Lime hydration**



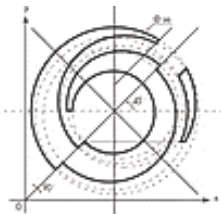
- **SO₂ absorption**

- **Primary absorption**



- **SO₂ secondary oxidation (some minor part of the sulfite)**



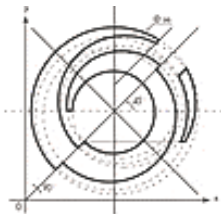


Semi-dry FGD Installation



- **Laziska Power Plant
Poland**
- **2 x 120 MWe**
- **95% SO₂ removal**
- **Start-up 1996**



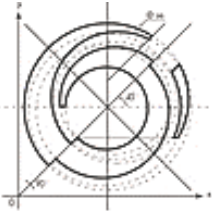


Laziska Power Plant

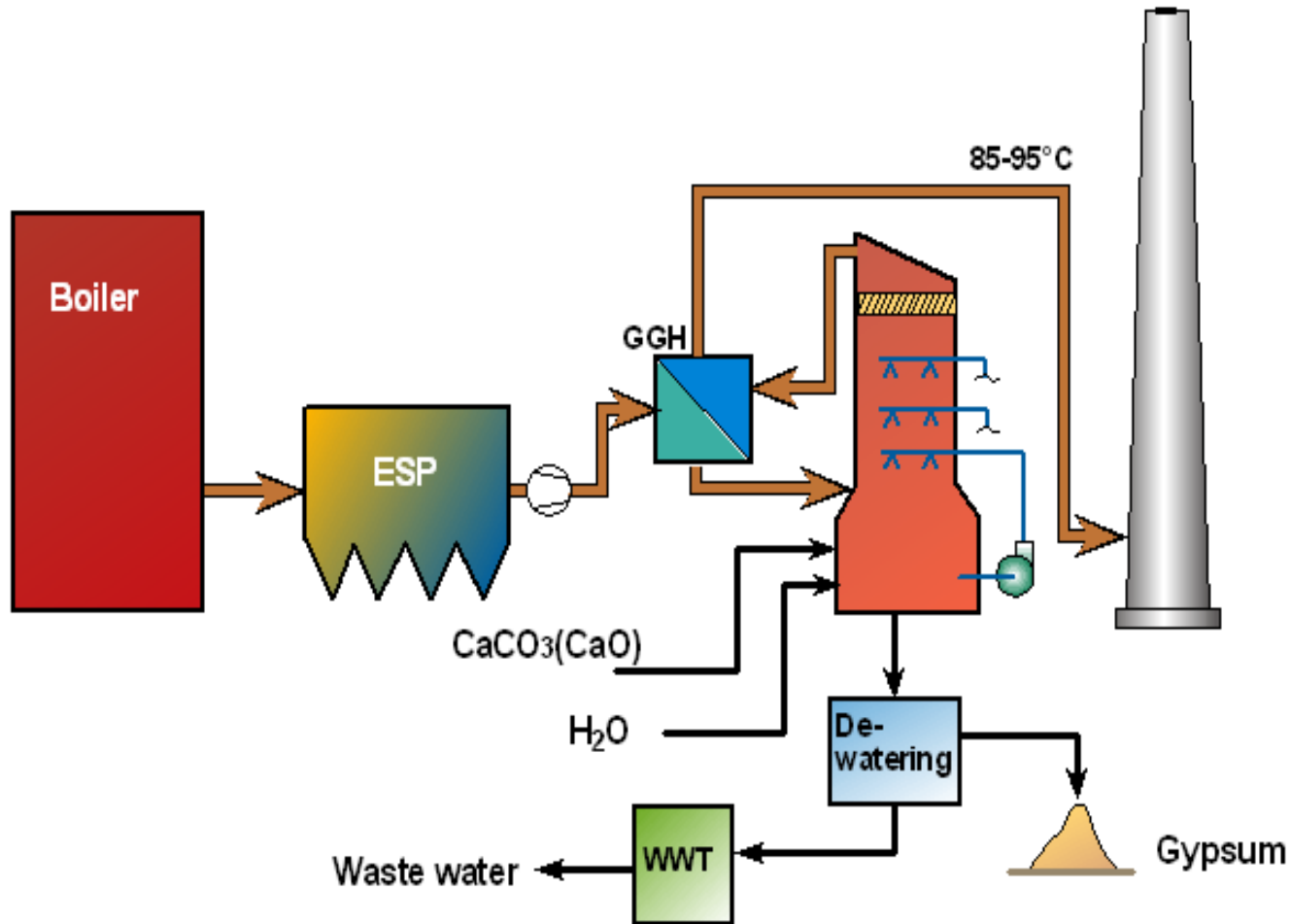
Semi-dry FGD installaton

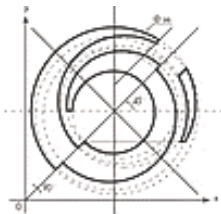


Power production	2 x 120 MW
Main fuel	Coal, max. 1.4% S
Flue gas flow	2 x 518'000 Nm ³ /h
Temperature	max. 165 °C
SO ₂ inlet	1'500 - 4'000 mg/Nm ³
SO ₂ removal efficiency	95% (80 % guaranteed)
Absorbent	CaO
Dust load, inlet NID	max. 22 g/Nm ³
Dust emission	15 mg/Nm ³ (50 mg/Nm ³ guaranteed)
End product conveying	Dense phase pneumatic system (1.2 km)
End product	To fill coal mines
In operation	Year 1996



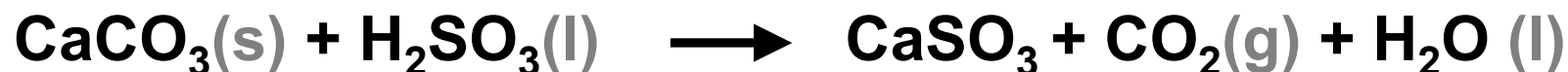
Wet FGD Process Description



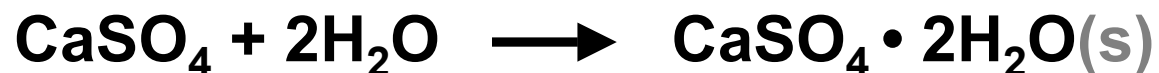


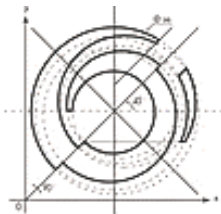
Spray towers

- **Primary reactions (absorption/neutralization)**



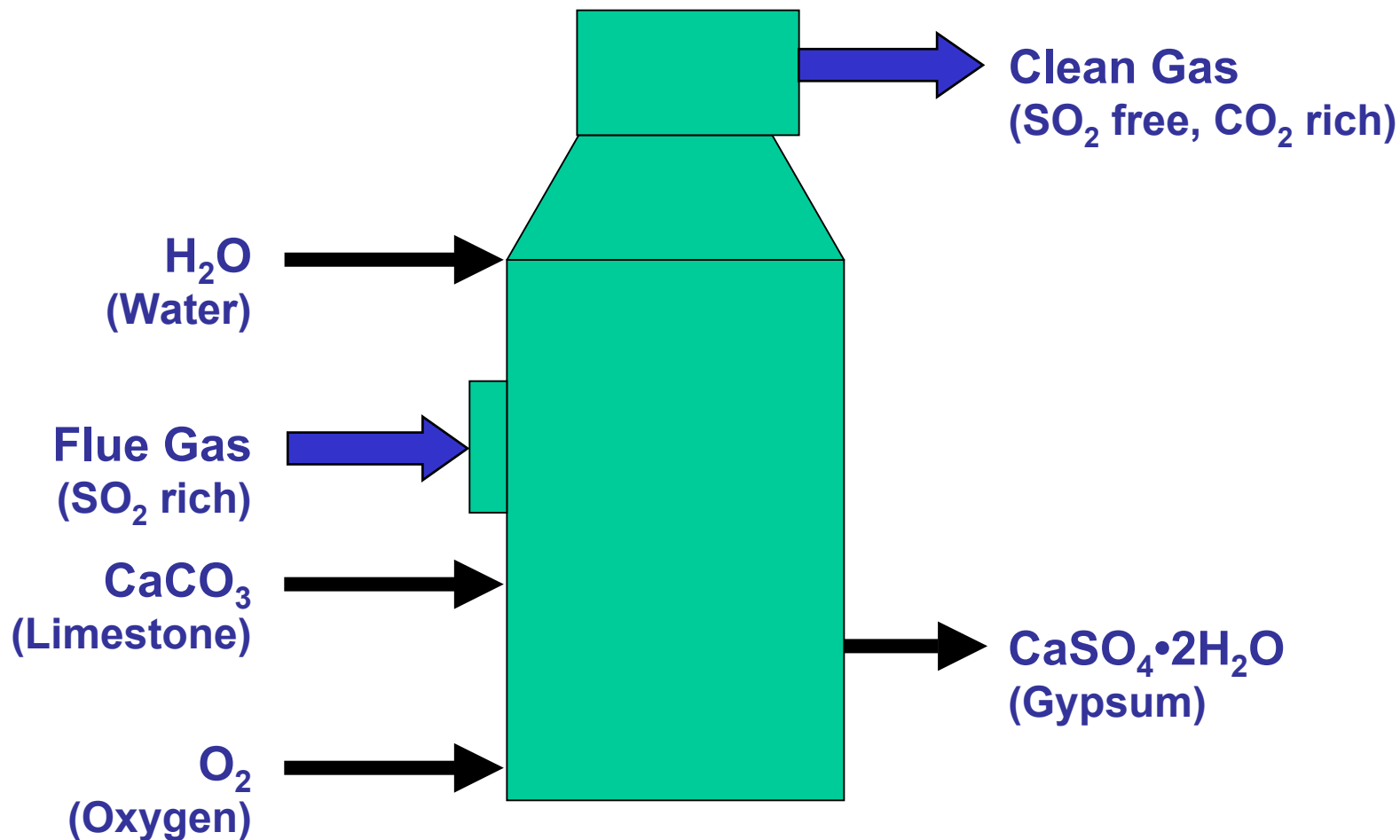
- **Secondary reactions (forced oxidation/crystallization)**

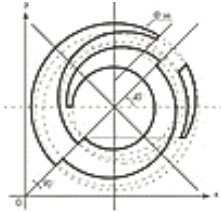




Wet FGD Process Description Spray Towers

Spray towers



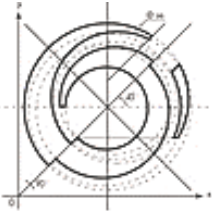


WET FGD Installation Spray Towers in Stack

Spray towers

- **ZEPAK Konin
Poland**
- **2 x 55 MWe**
- **95% SO₂ removal**
- **Start-up 1997**

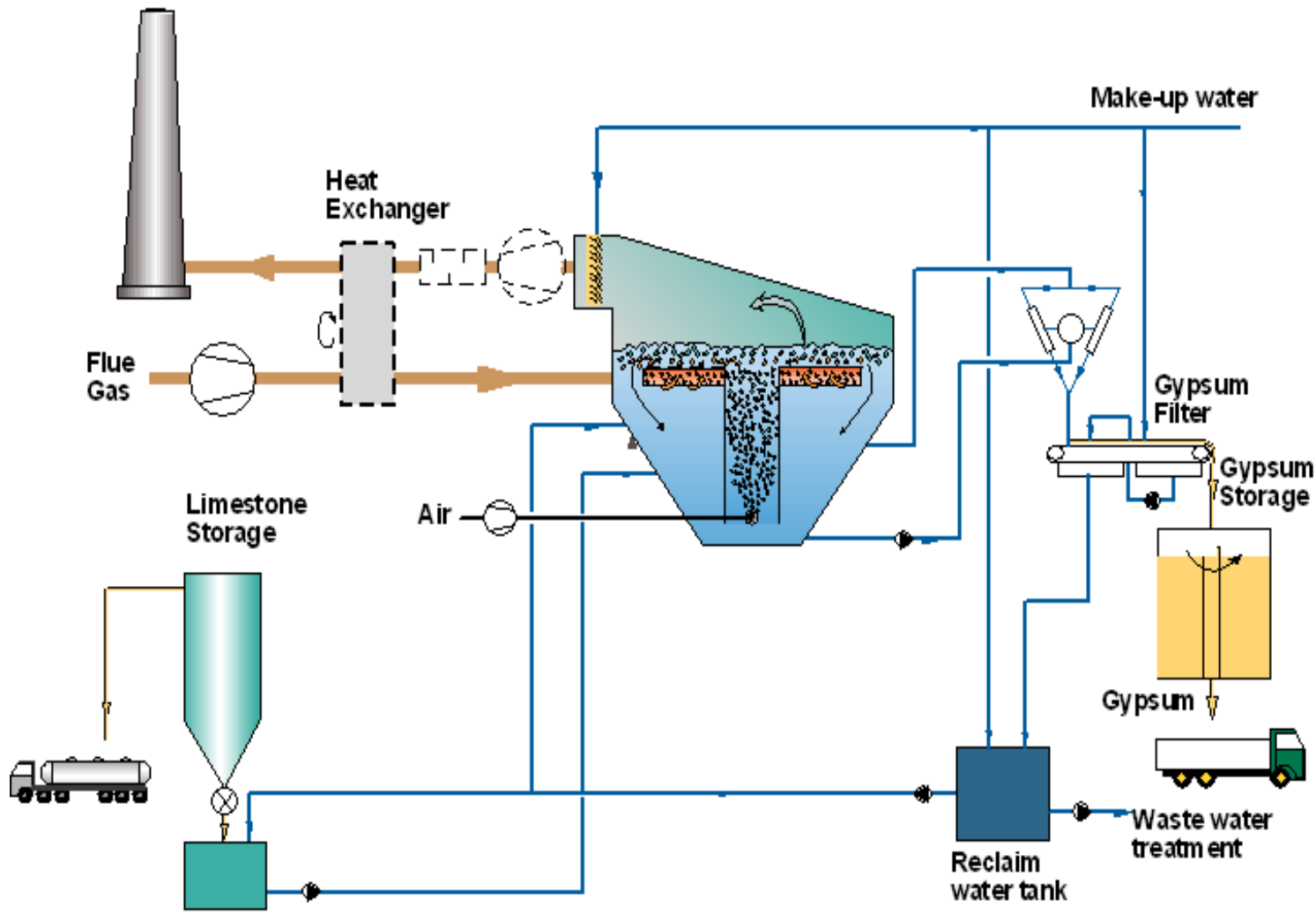


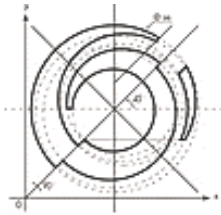


Flowpac Process Description



Flowpac (Commercial Grade Gypsum)

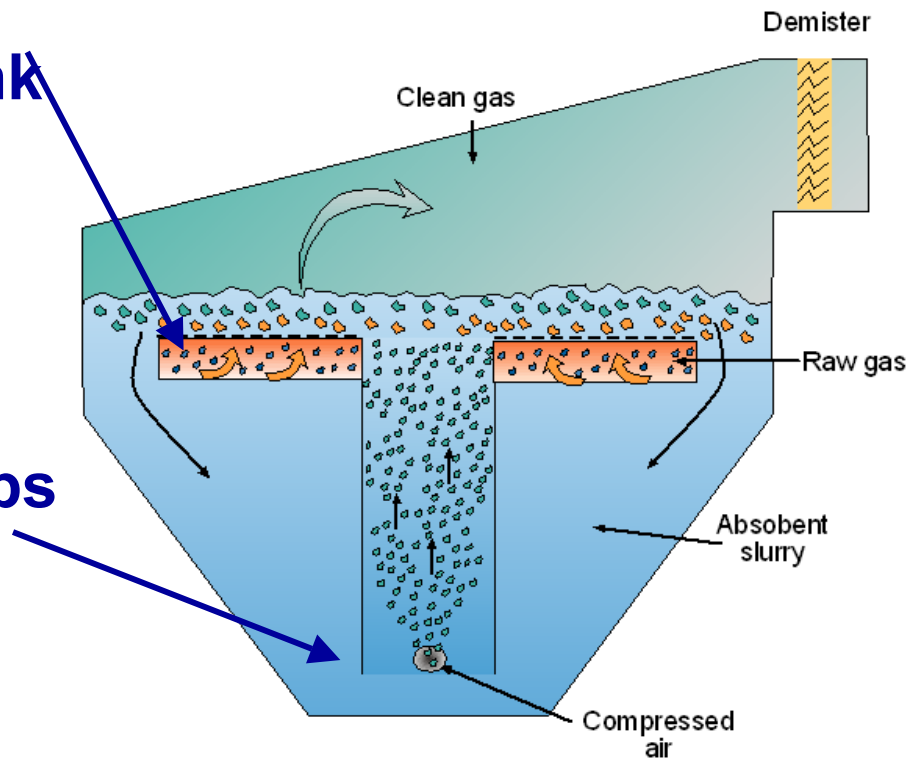


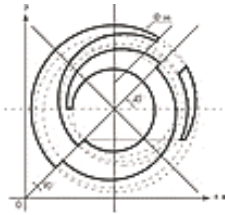


Flowpac Reactor

Flowpac

- Tray weeping drops into the tank (Turndown 1:5)
- Oxidation air keeps slurry in suspension

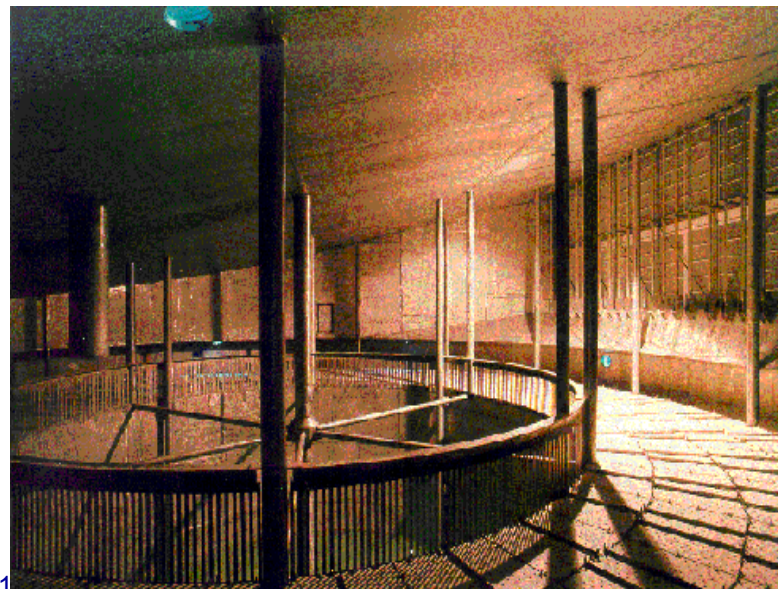


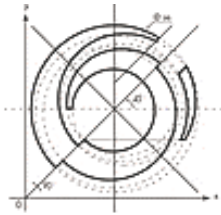


Flowpac Absorber View

Flowpac

- **In operation**
Absorber and sieve tray
at 20% flue gas flow
and 80% slurry bed height
- **Empty absorber**



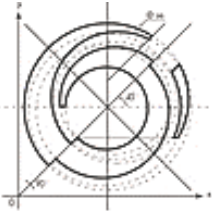


Flowpac Installation

Flowpac

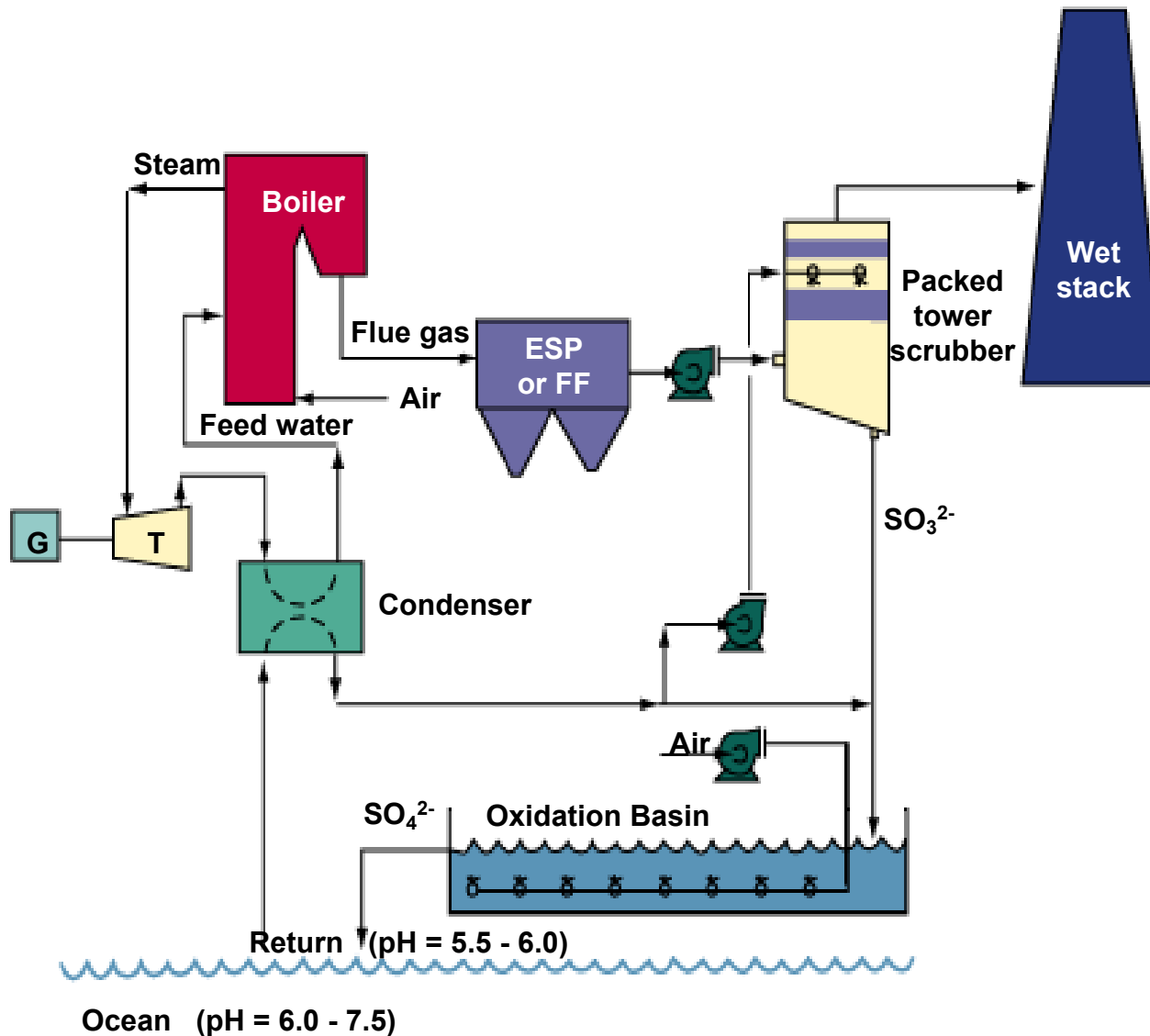
- **Karlshamn Power Plant
Sweden**
- **1 x 340 MWe**
- **99% SO₂ removal***
- **Start-up 1997**

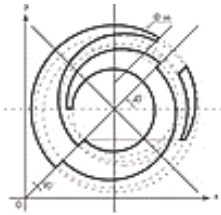




Sea Water FGD Process Description **ALSTOM**

Sea Water





Main Chemical Reactions Steps

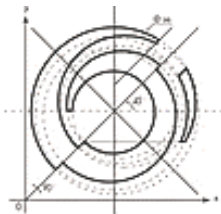
Sea Water

- **Primary reaction**



- **Secondary reaction (oxidation)**





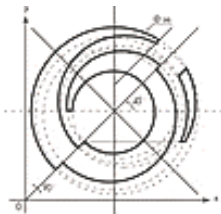
Sea Water FGD Installation



Sea Water

- **Water treatment plant**

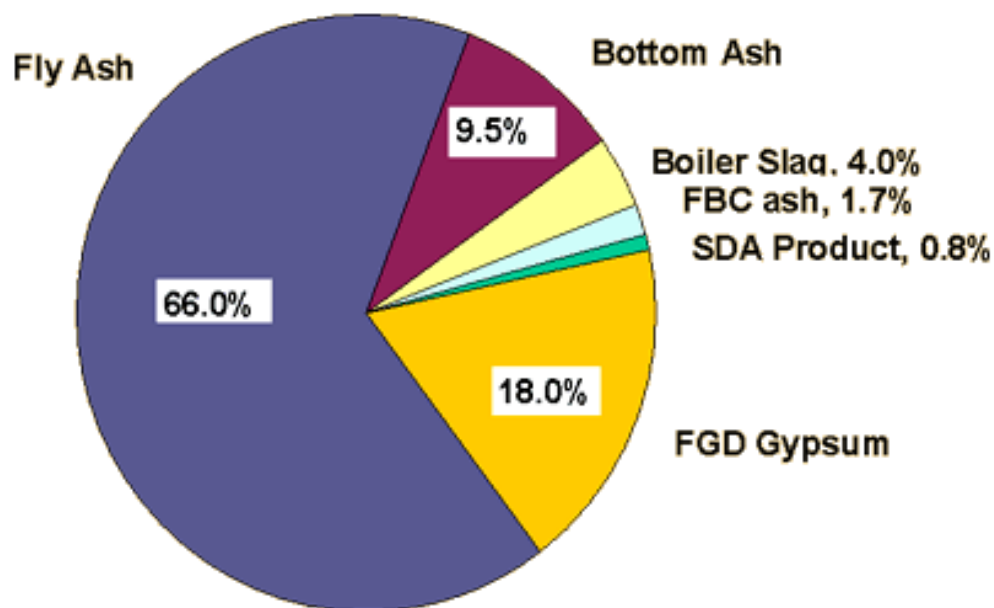




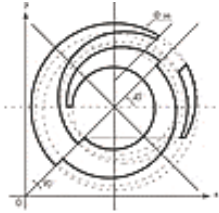
Coal Combustion Products*



Production distribution (Europe, 2000)

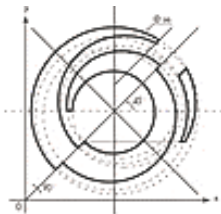


Components	Production [Mton]
Fly ash	38.96
Bottom ash	5.58
Boiler slag	2.35
FBC ash	1.02
FGD gypsum	10.64
SDA product (Dry FGD)	0.46
Others	0.27

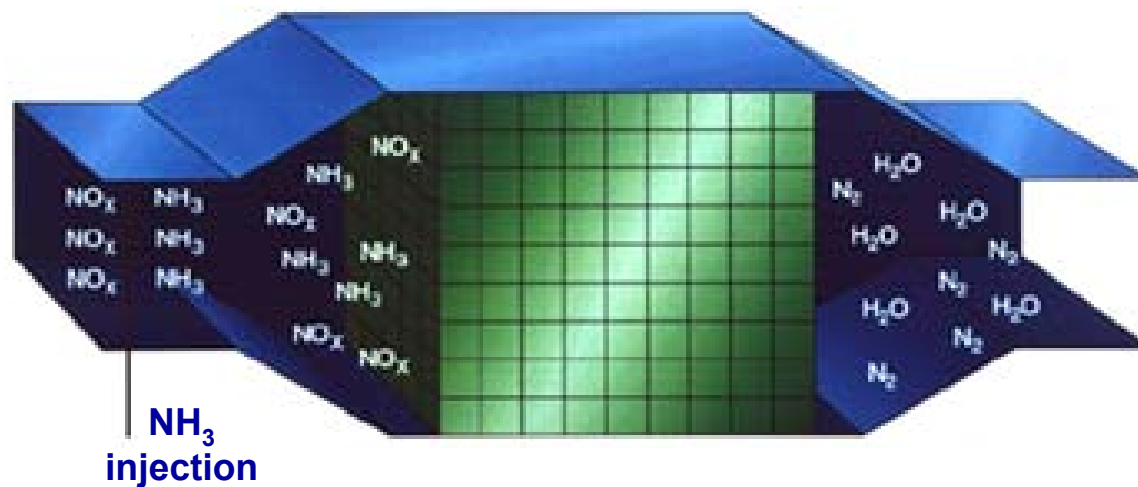


Agenda

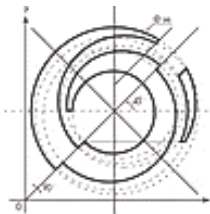
- Emissions trend
- Future trends in regulations and technologies
- Technological options
 - Gaseous emissions: Nitrogen Oxides
 - Particulate emission



Chemical Reactions



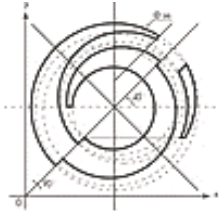
Active Catalyst: Vanadium and Tungsten



DeNOx Technology

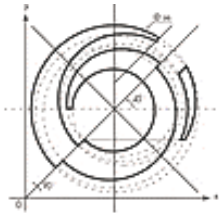
- High Dust SCR
 - Most cost-effective solution
- Typical Reactor Configuration:
 - Gas flows vertically down
 - 2 to 3 layers of catalyst (one can be un-installed spare layer)
 - Ammonia injection before duct elbow
- Cautions :
 - SO_2 to SO_3 oxidation
 - Catalyst channel size (pitch)





Agenda

- Emissions trend
- Future trends in regulations and technologies
- Technological options
 - Gaseous emissions
 - Particulate emission



Particulates Electrostatic Precipitators (ESP)

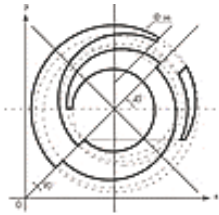


**A well-established APC
technology:**

- **Dry and Wet ESPs**
- **Emissions level
down to 1 - 2 mg/Nm³**



**ELSAM A/S
Ensted Plant - 640 MW
Aabenraa, DK**



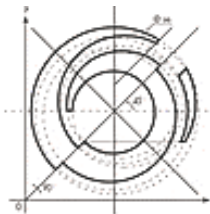
Particulates Fabric Filters (FF)



- **High and Low Ratio Filter designs available**
- **Extensive range of fabrics**
- **Optimized cleaning cycles to extend Fabric life**
- **New and retrofit applications**
- **Designs to meet stringent worldwide regulatory requirements**



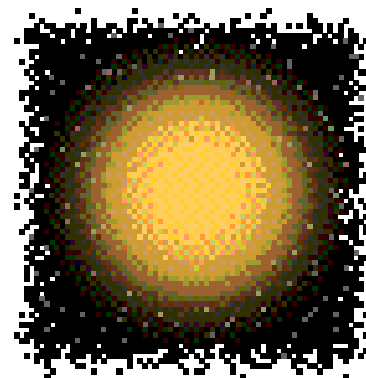
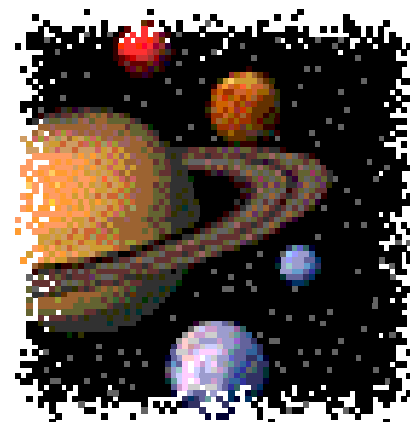
**Nevada Power Company
Reid Gardner Unit 4 - 245 MW
Moapa, Nevada, USA**



Future Environmental Legislation



- With or without specific emissions targets, the World is expecting cleaner, more affordable energy, whatever the current technical and economic obstacles. This “demand” is political, not economic. If the energy industry does not deliver, the politics may become less flexible.



The logo features the word "ALSTOM" in a bold, sans-serif font. The letters "A", "L", "S", "T", and "M" are dark blue, while the letter "O" is red and stylized as a circular graphic with three concentric rings. The logo is centered within a white, semi-circular shape that is partially overlaid by a thick red arc. The background consists of vertical blue stripes of varying shades and some faint, light blue curved lines.

ALSTOM

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