

# Near Zero Emission Clean Coal Technology

Greg Kelsall  
20/06/2007

POWER SYSTEMS |

**ALSTOM**

# Agenda

1st topic      ALSTOM Background

2nd topic      The need and ALSTOM approach

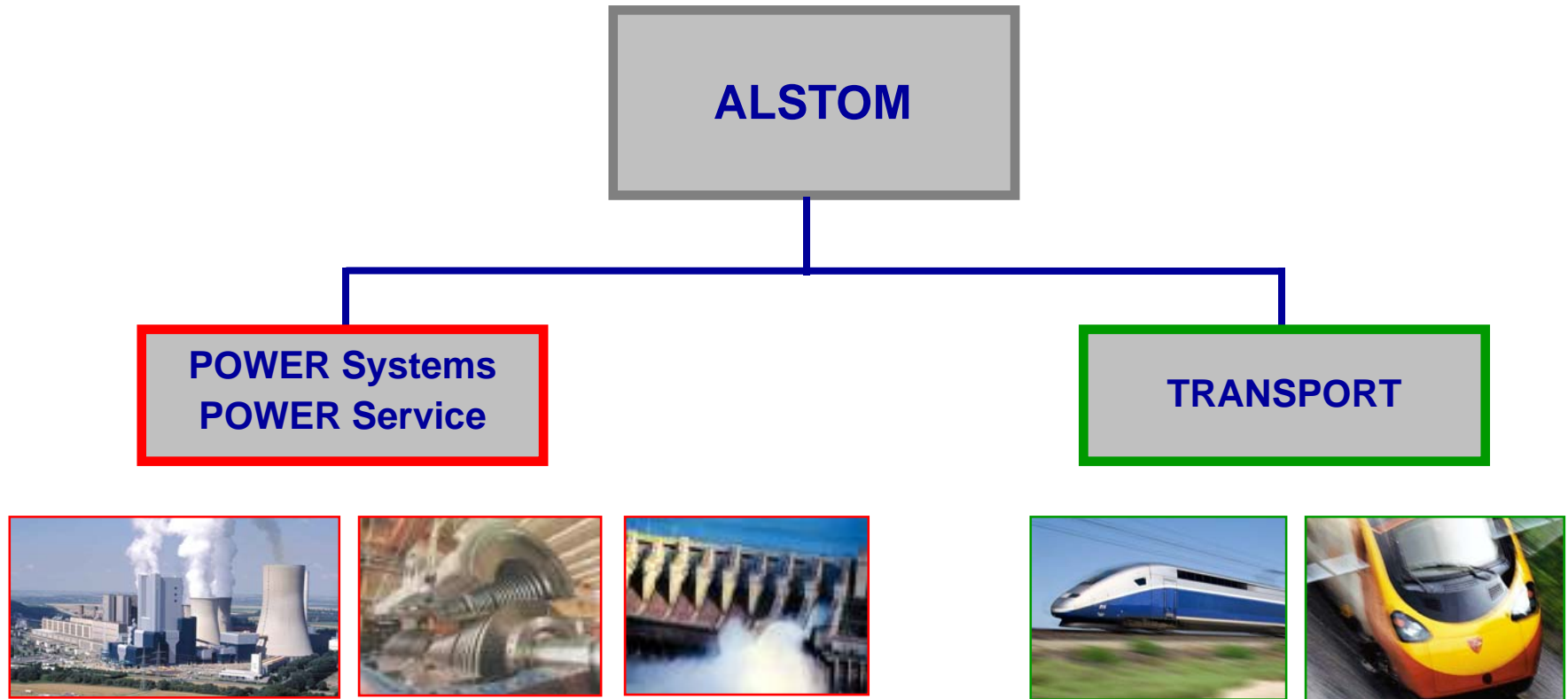
3rd topic      CO2 Reductions Now/Near Term

4th topic      CO2 Capture Medium Term

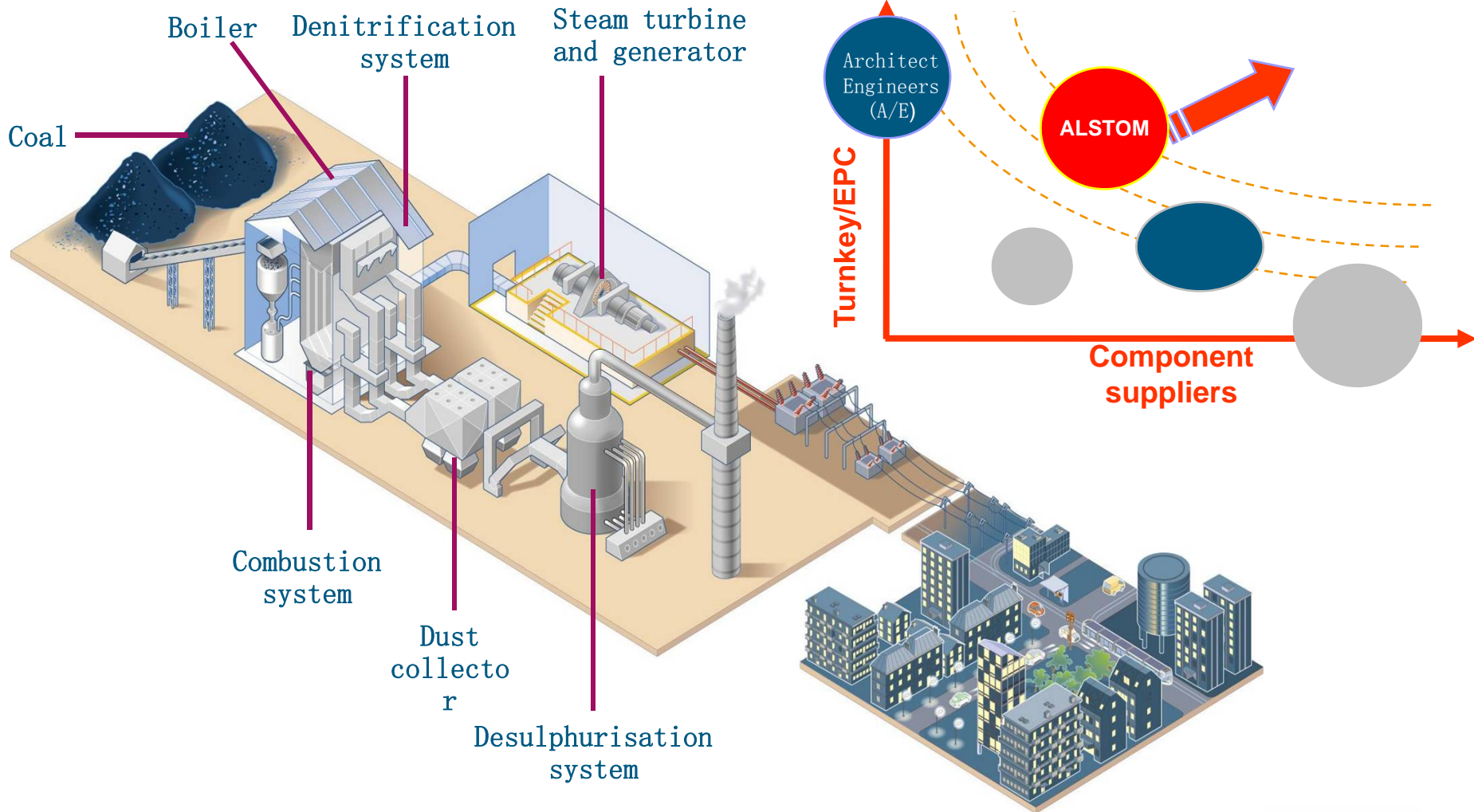
5th topic      Fuel Flexible Gas Turbines

6th topic      ALSTOM Priorities

# ALSTOM Group Organisation



# Complete range of solutions



# Agenda

1st topic      ALSTOM Background

2nd topic      The need and ALSTOM approach

3rd topic      CO2 Reductions Now/Near Term

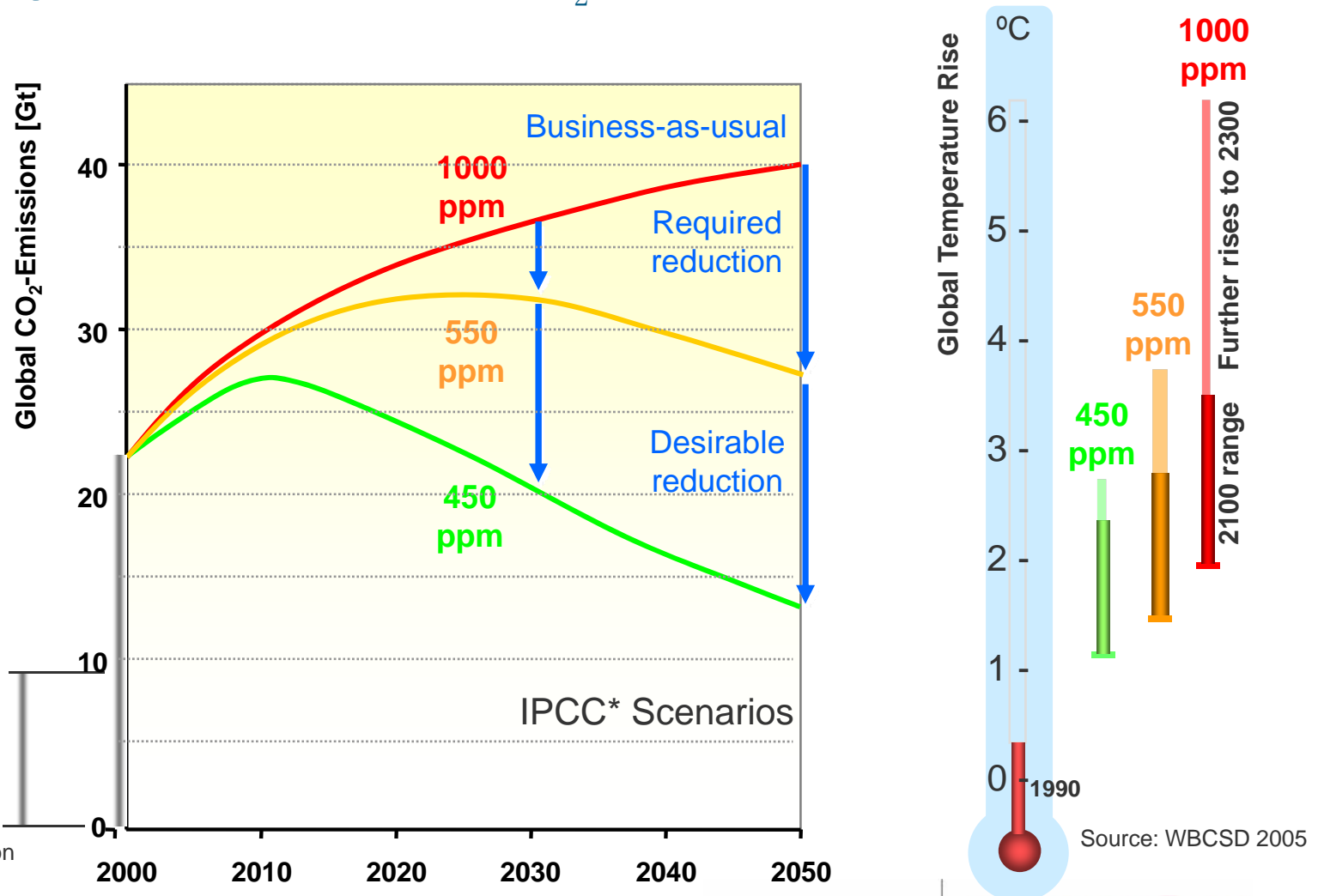
4th topic      CO2 Capture Medium Term

5th topic      Fuel Flexible Gas Turbines

6th topic      ALSTOM Priorities

# Outlook of global CO<sub>2</sub> emissions

Goal: A longterm moderate stable CO<sub>2</sub> concentration in the atmosphere



\* Intergovernmental Panel on Climate Change

# ALSTOM strategy for CO<sub>2</sub>

	Near Term	Medium to Long Term
Installed base	<ul style="list-style-type: none"><li>• Integrated retrofit offerings with higher efficiency and STs</li><li>• Fuel switch</li><li>• Biomass co-firing</li></ul>	<ul style="list-style-type: none"><li>• CO<sub>2</sub> post-combustion capture products: amine, ammonia, oxy-combustion for retrofit</li><li>• Advanced cycles retrofit</li></ul>
New power plants	<ul style="list-style-type: none"><li>• Fuel flexibility via CFBs</li><li>• 620 C best available technology for improved efficiency</li><li>• CO<sub>2</sub> ready power plant concept</li></ul>	<ul style="list-style-type: none"><li>• Integrated CO<sub>2</sub> post-combustion capture or oxy-fuel firing and chemical looping</li><li>• 700 C USC boilers &amp; STs</li><li>• Gasification for polygeneration</li></ul>

Clean Combustion = limiting emissions while maintaining power plant economics

# Agenda

1st topic      ALSTOM Background

2nd topic      The need and ALSTOM approach

3rd topic      CO2 Reductions Now/Near Term

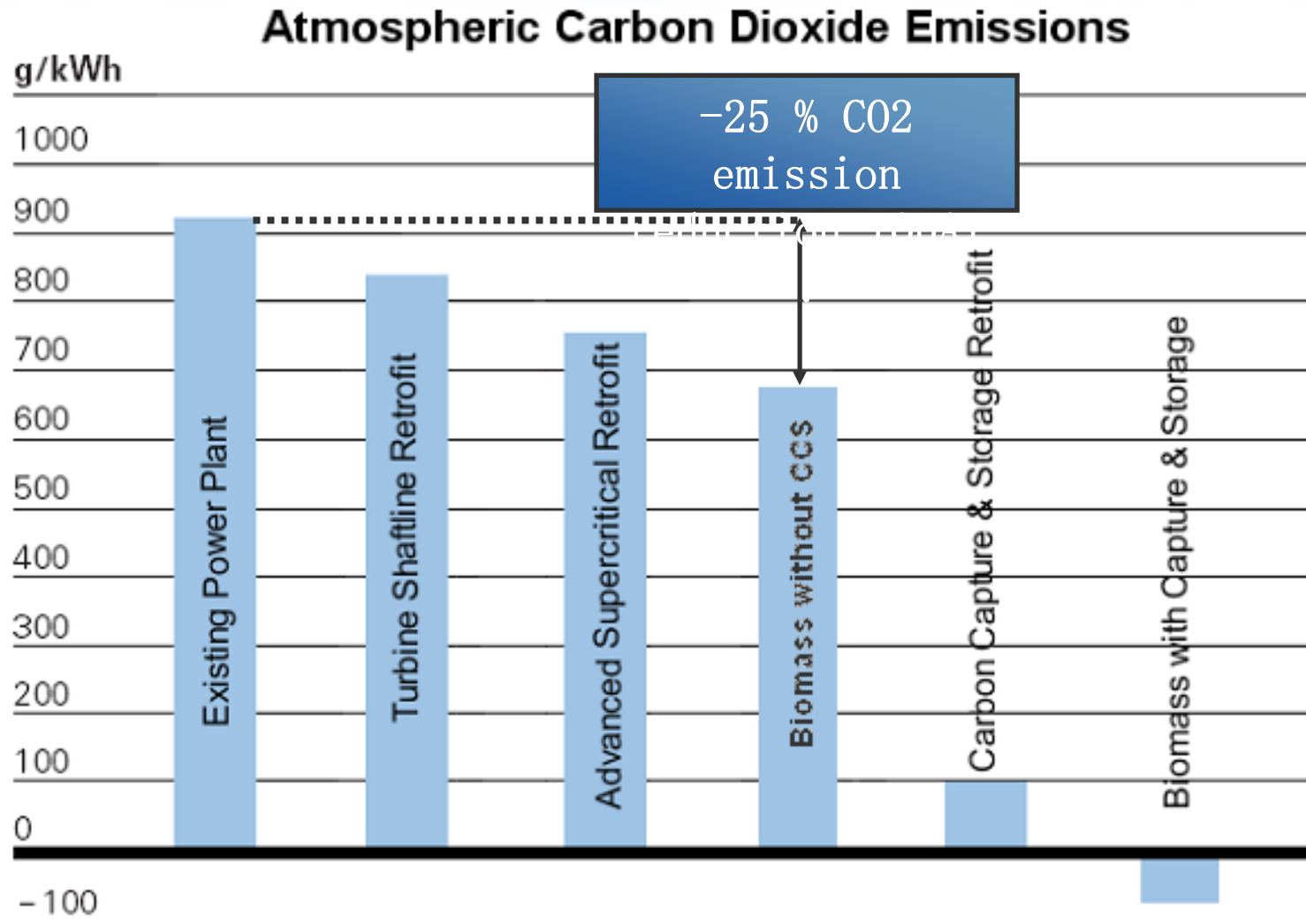
4th topic      CO2 Capture Medium Term

5th topic      Fuel Flexible Gas Turbines

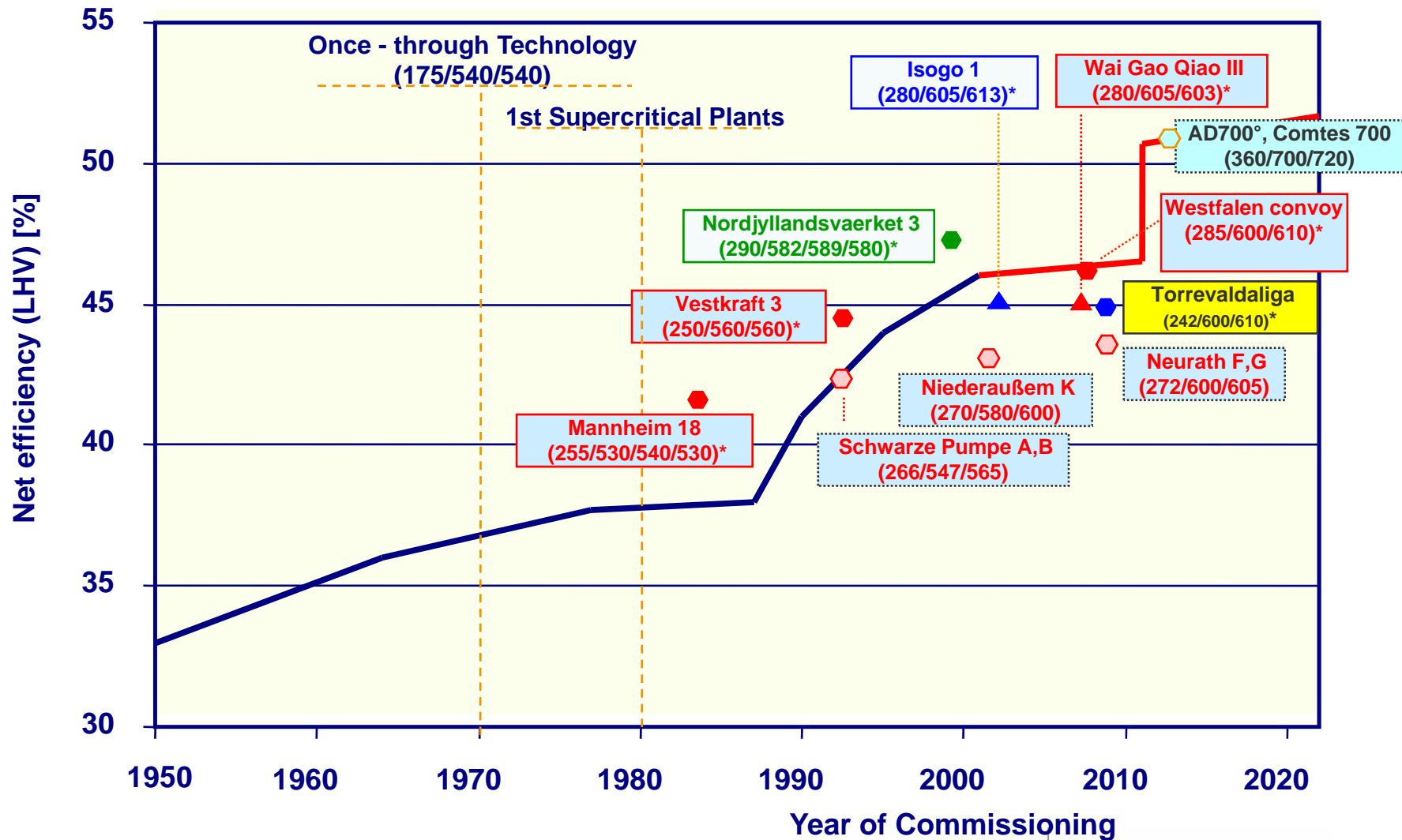
6th topic      ALSTOM Priorities



Retrofit = Immediate CO<sub>2</sub> avoidance

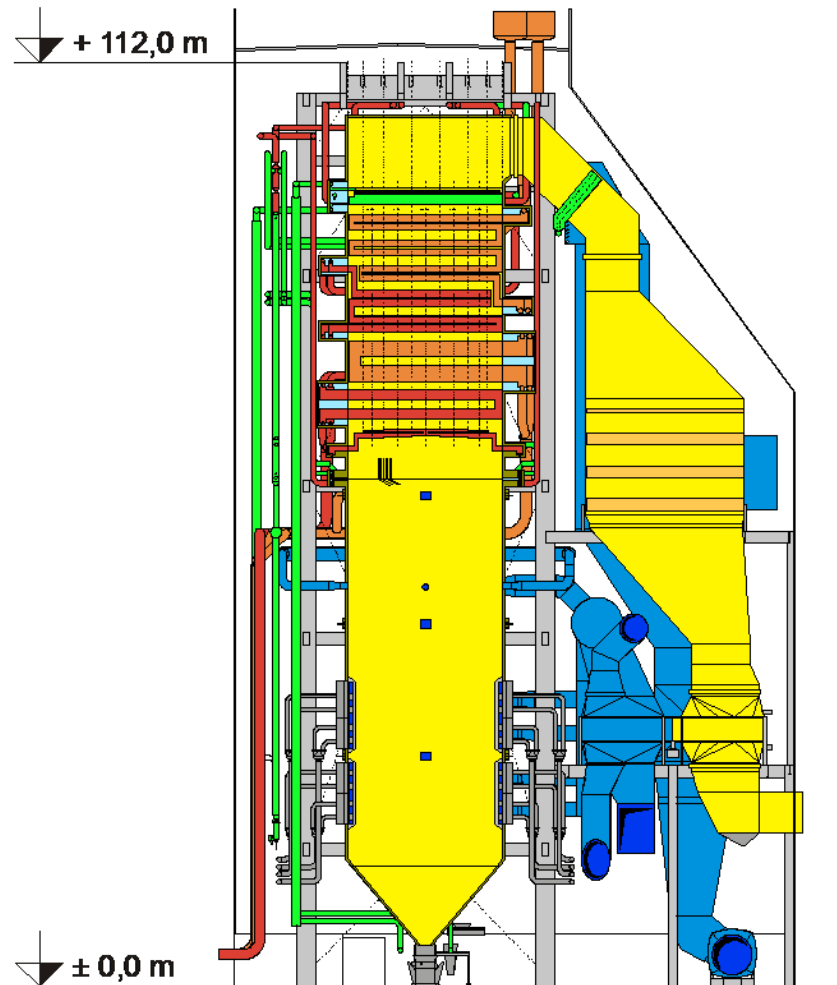


# Efficiencies of coal fired power plants in Europe



# Karlsruhe, Unit 8, 890 MW

## Latest Order: Boiler and Turbine for ALSTOM



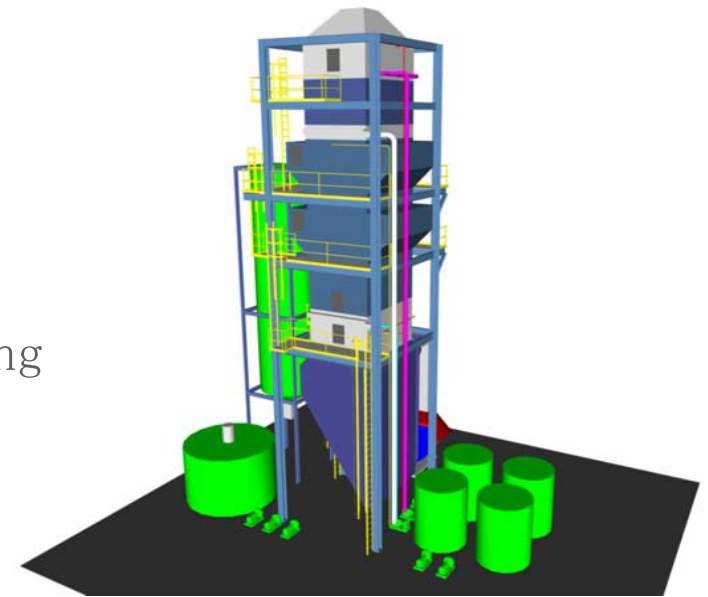
### Karlsruhe, Unit 8, 890 MW

- Technology – Once Through
- Fuel – Bituminous Coal
- Capacity t/h 2.347
- Pressure bar 285
- Temperature ° C 603/621
- Exit gas temperature ° C 120
- Boiler efficiency (LHV) % 95
- Country – Germany
- Customer – EnBW

# Evolution of air pollution controls

## Emissions continue to advance toward zero

- Today state of art
  - $\text{SO}_2$  >> 99% capture with Wet FGD and DBA
  - $\text{NO}_x$  >95% reduction with SCR
  - Particulates >> 99.99% capture
  - Hg > 70– 95% capture (coal dependent)
- Next steps
  - Continuous improvements to existing technology
  - Multi-pollutant systems to reduce costs
  - High Hg capture on all coals (w/o reliance on ACI)
  - Introduction of  $\text{CO}_2$  capture



# Agenda

1st topic      ALSTOM Background

2nd topic      The need and ALSTOM approach

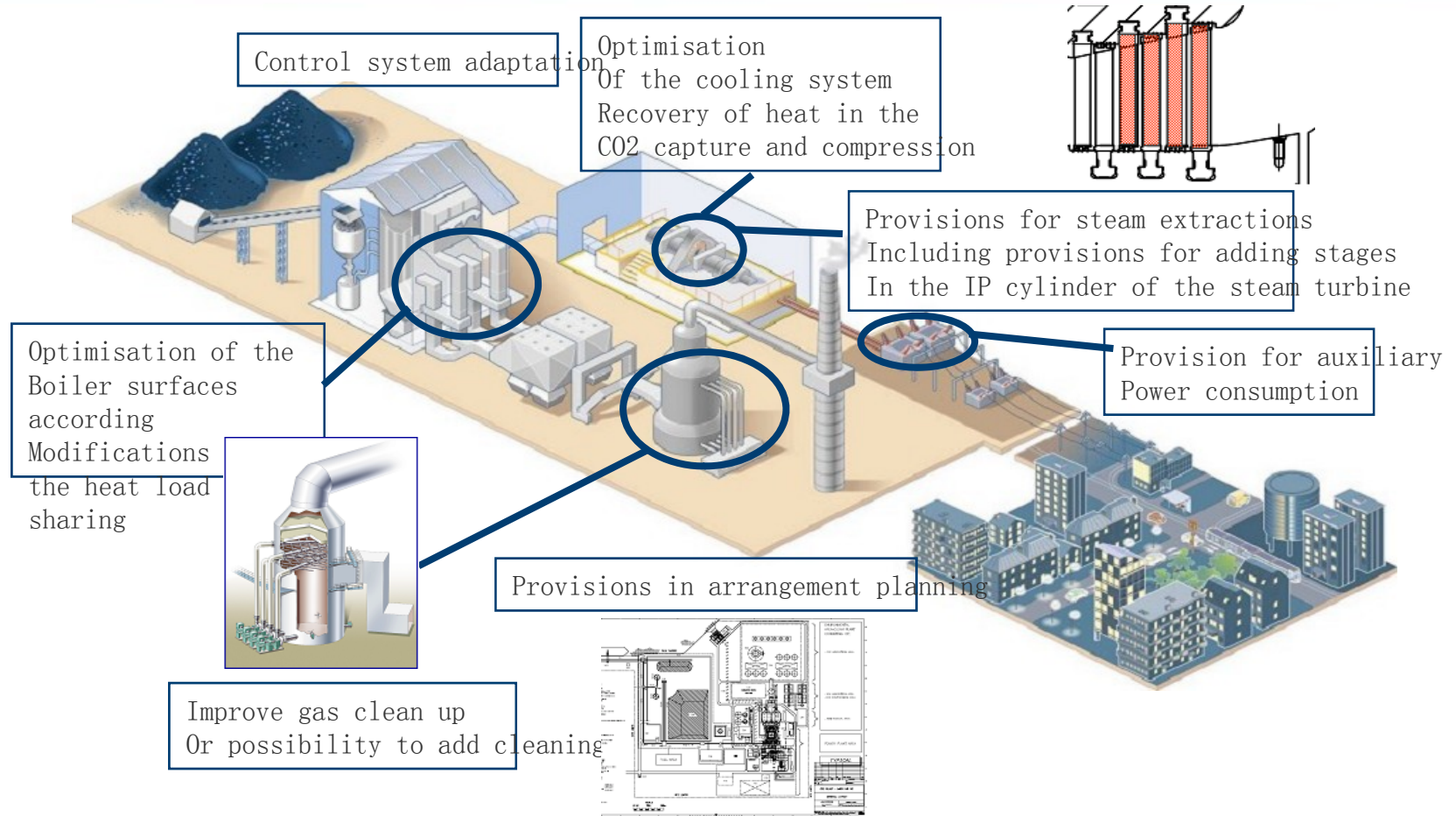
3rd topic      CO2 Reductions Now/Near Term

4th topic      CO2 Capture Medium Term

5th topic      Fuel Flexible Gas Turbines

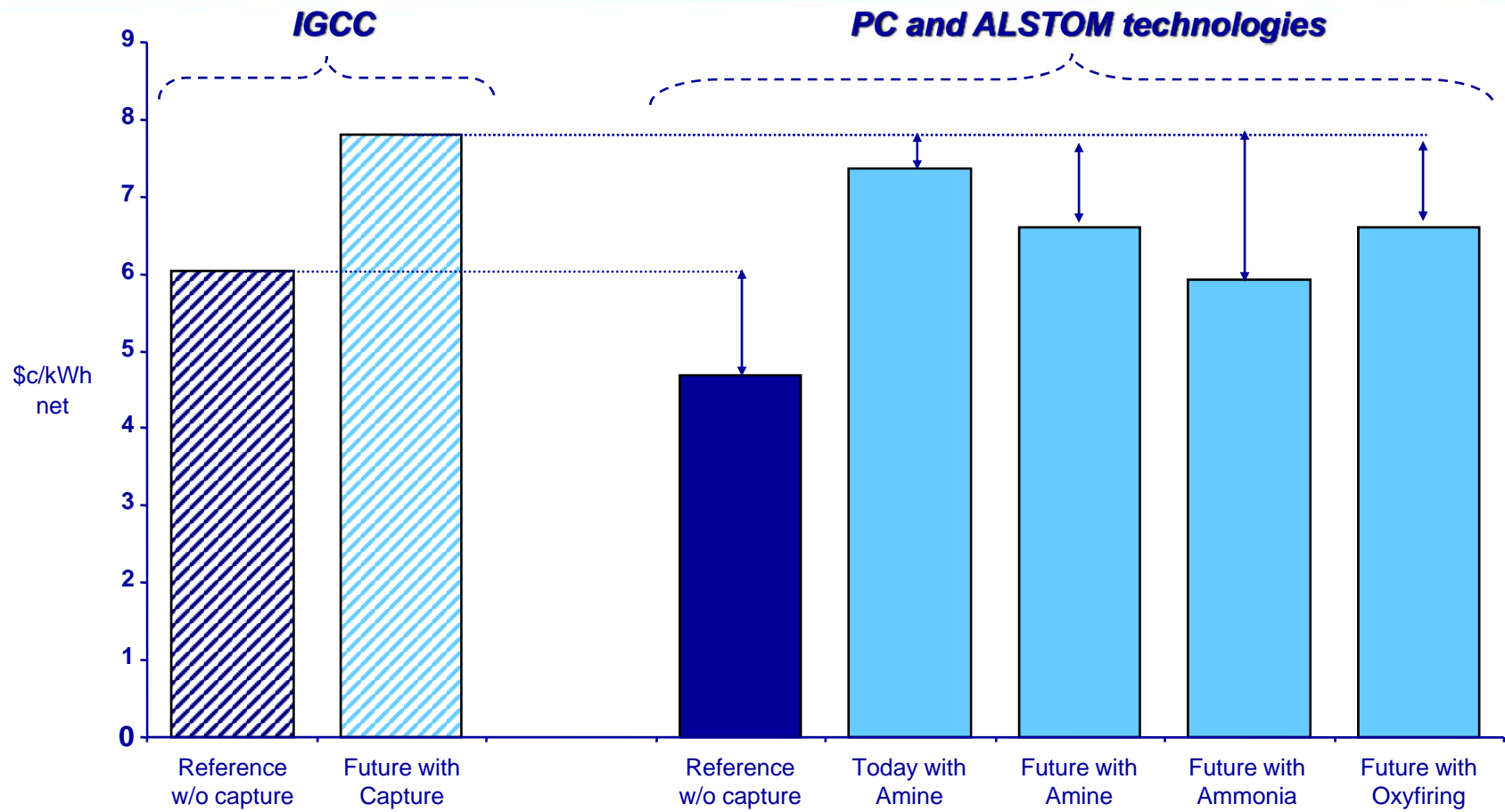
6th topic      ALSTOM Priorities

# CO<sub>2</sub> “Capture Ready” coal power plant



An integrated approach is key

# Cost of electricity of an 800MW coal plant with CO<sub>2</sub> capture



A set of new technologies is under development. The market will choose according to demonstrated cost of electricity including CO<sub>2</sub> capture



# Retrofittable CO<sub>2</sub> capture solutions

## Oxy-combustion: 30 MW<sub>th</sub> Oxyfuel Pilot Plant

CO<sub>2</sub>-free coal-fired pilot plant at 'Schwarze Pumpe' site based on Oxyfuel technology (planned)

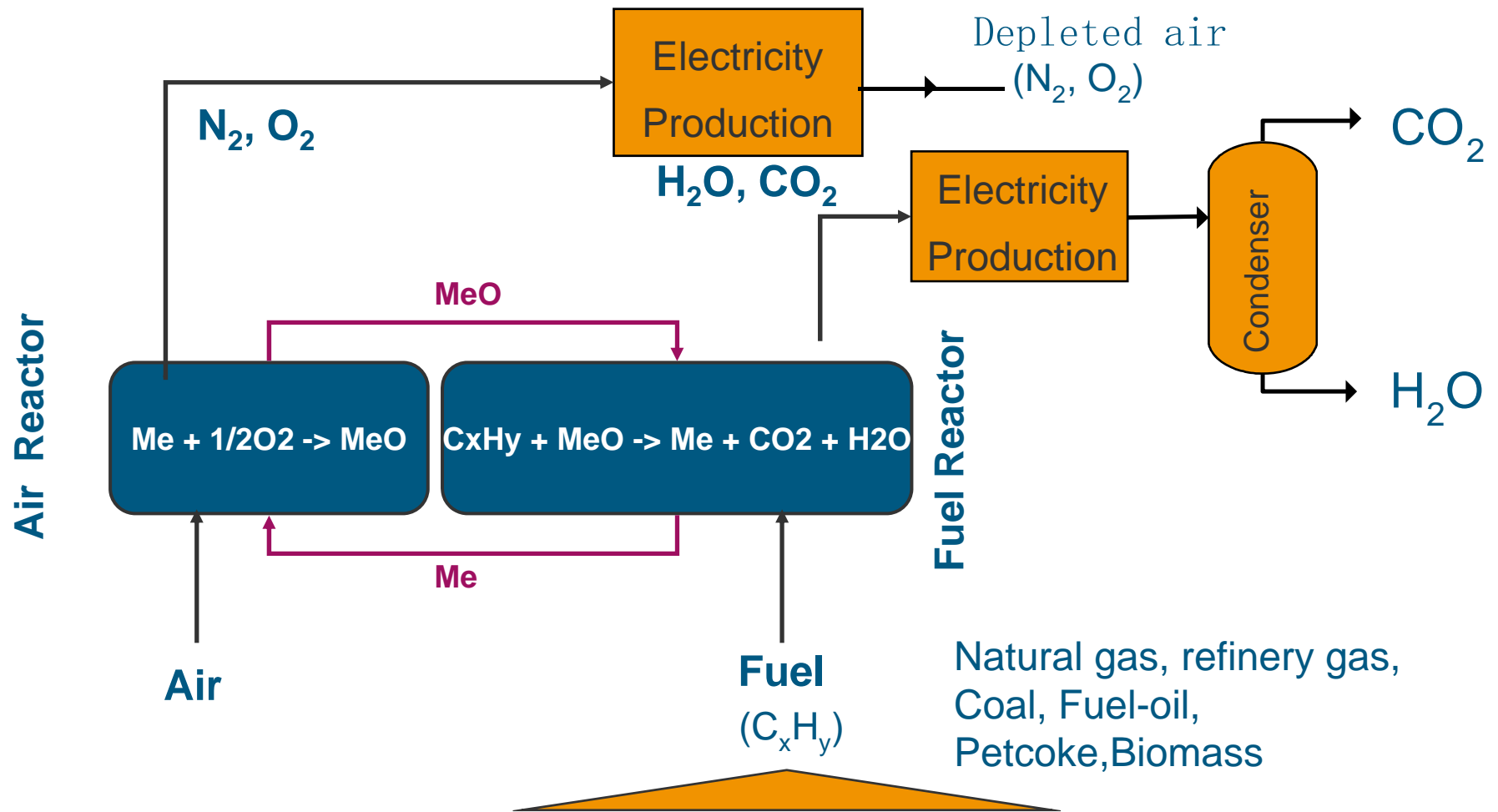


- Large quantity of O<sub>2</sub> required
- CO<sub>2</sub> separation with no use of chemicals
- Smaller boiler and flue gas volume reduction  
(Low NO<sub>x</sub>)



# CO<sub>2</sub> capture solutions

## Oxy-combustion: Chemical looping metal oxides



# Retrofittable CO<sub>2</sub> capture solutions

## Post Combustion Solutions for New Plants and Retrofit

### CO<sub>2</sub> absorption processes (MEA, MDEA)



PP Esbjerg (DK)

- Available in commercial scale
- Retrofittable and flexible
- High energy demand for regeneration of solvents

Alternative processes:

e.g. Frosting



1 t CO<sub>2</sub>/h pilot plant  
(CASTOR EU-FP6)

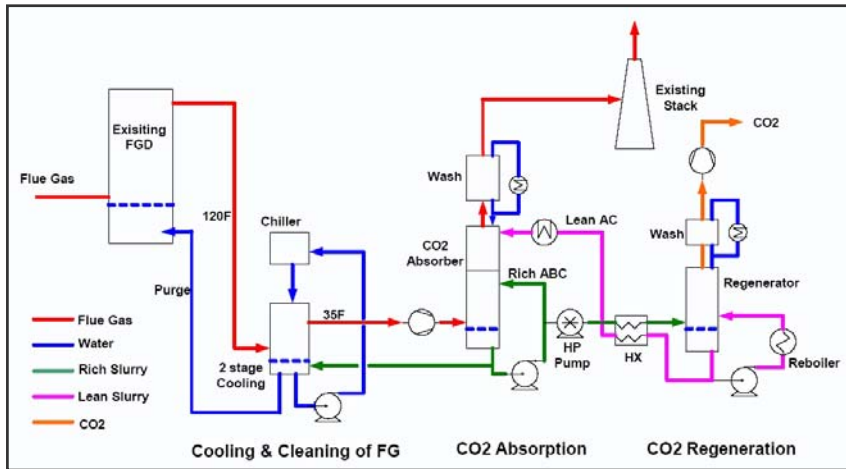


CO<sub>2</sub> freezes on  
cooling fins

# Retrofittable CO<sub>2</sub> capture solutions

## Chilled Ammonia Process

A promising technology for post combustion carbon capture



### Principle

- Ammonia (NH<sub>3</sub>) reacts with CO<sub>2</sub> and water. It forms ammonia carbonate or bicarbonate
- Moderately raising the temperatures reverses the above reactions - releasing CO<sub>2</sub>



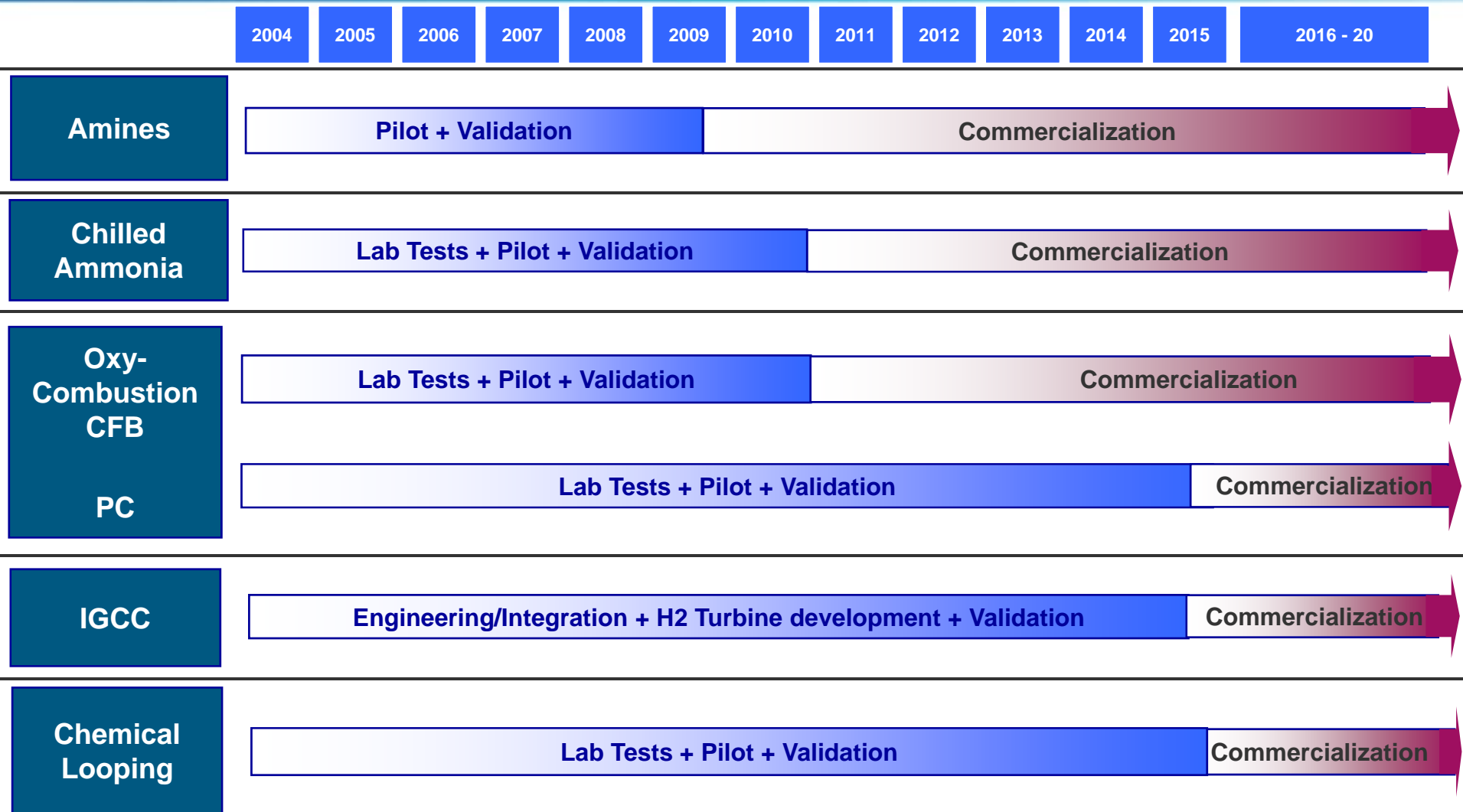
5 MW Pilot Plant (USA) Start-up anticipated for 2007

### Advantages

- High efficiency capture of CO<sub>2</sub> and low heat of reaction
- Low cost reagent
- No degradation during absorption-regeneration
- Tolerance to oxygen and contaminations in flue gas

# CO<sub>2</sub> capture solutions

## Time-line of CO<sub>2</sub> capture processes



# Agenda

1st topic      ALSTOM Background

2nd topic      The need and ALSTOM approach

3rd topic      CO2 Reductions Now/Near Term

4th topic      CO2 Capture Medium Term

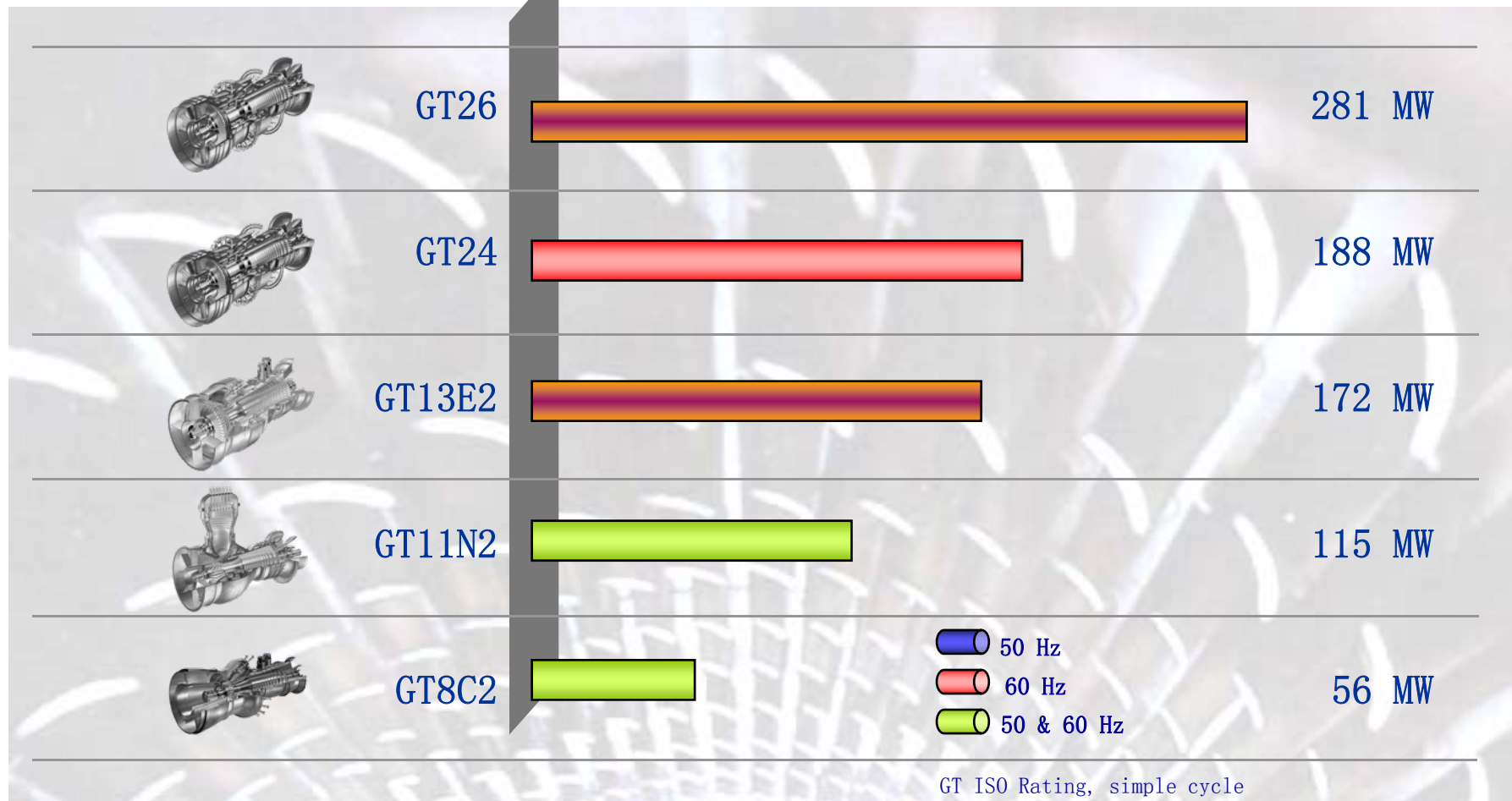
5th topic      Fuel Flexible Gas Turbines

6th topic      ALSTOM Priorities



# Gas turbine portfolio

Gas Turbines from 56 MW to 281 MW



# Fuel compositions experience

## A Broad Range of Fuels Handled Successfully

- ALSTOM experience in fuel gas composition:
  - Standard pipeline gas : LHV = 35 MJ/kg – 50 MJ/kg
  - Dilution with CO<sub>2</sub> / N<sub>2</sub>: LHV down 20 MJ/kg  
(Wobbe Index WI = 22 MJ/m<sup>3</sup>)
  - C<sub>2</sub>+ content: up to 22 vol%
  - H<sub>2</sub> content: up to 85 vol%
  - Syngas: LHV = 7 MJ/kg – 14 MJ/kg
  - Steel work gas: LHV = 2 MJ/kg – 4 MJ/kg

# GT13E2 with MBTU fuel

- IGCC Plant fired with refinery residues
- 290 MWe at 40.8% cycle efficiency
- Minimum modification to standard GT 13E2
- Dual-fuel capability
  - diluted syngas
  - Oil
- Commercial in 2001





# Experience base on Hydrogen fuels

## Key Targets & Technology Elements

- Gas Turbine Burner for Hydrogen (up to 90%)
- Benchmarking against Existing Technologies
- Enabling Technologies for CO<sub>2</sub> Storage



The screenshot shows the ENCAP project website. The header features the 'encapco2' logo and the title 'ENHANCED CAPTURE OF CO<sub>2</sub>'. A navigation bar includes links for Home, Project Overview, Project News, Publications, Events, Links, and Contact Info. The main content area is titled 'The ENCAP Project' and contains a detailed description of the project's objectives, a 'Latest News' section dated 7/2/2005, and a 'Statistics of the website Visits' table. The left sidebar mentions 'PROJECT HOTEL e-Room' and funding by the European Union under FP 6. A green box at the bottom right provides key project details.

**PROJECT HOTEL**  
e-Room

Funded by the European Union  
FP 6 Integrated Project

### The ENCAP Project

ENCAP is a project whose objective is to develop new pre-combustion CO<sub>2</sub> capture technologies and processes for power generation. It aims at technologies which meet a target of at least a 90% CO<sub>2</sub> capture rate and a reduction in the cost of capture of 50% compared to present. The future large-scale development of these technologies will depend on significant improvements in their cost and other aspects that may improve their competitiveness against conventional energy sources and renewables. The results from ENCAP will enable power companies to decide to launch a new design project by 2008-2010 aimed at a large demonstration plant with the potential for wide commercial exploitation in the horizon of 2015-2020.

**Latest News:**  
7/2/2005  
Comments on the ENCAP Web Site  
[>>Read more...](#)

Statistics of the website Visits	
Total number since the starting date (as of end of previous month) :	5773
Peak of monthly visits (Jul 2005) :	980
Second peak of monthly visits (Aug)	864

**Starting Date:** 01/03/04  
**Project Duration:** 60 months  
**Budget:** 22,171,000€  
**Coordinator:** Vattenfall AB  
**Contact Person:**

# Agenda

1st topic      ALSTOM Background

2nd topic      The need and ALSTOM approach

3rd topic      CO2 Reductions Now/Near Term

4th topic      CO2 Capture Medium Term

5th topic      Fuel Flexible Gas Turbines

6th topic      ALSTOM Priorities

# Priorities summary

The ALSTOM logo is displayed in a bold, sans-serif font. The letters 'ALSTO' are in dark blue, and the letter 'M' is in red. The background of the slide features a blue sky with white clouds and a large, stylized circular graphic in the lower-left corner.

Clean Power Today !

- Retrofit and new equipment integration and optimisation
- Ultra super critical steam plant based on hard coal and lignite
- Multi pollution control for very low emissions of conventional pollutants
- Post-combustion CO<sub>2</sub> removal from both coal and gas plant
- Oxy-fuel combustion of solid fuel
- Fuel flexibility and H<sub>2</sub> for gas turbine
- Continued research and development



ALSTOM will remain active in the EU ZEP Technology Platform  
- helping set the strategy for Europe

[www.alstom.com](http://www.alstom.com)

**ALSTOM**