The Future for Coal Can Be CO_2 free?

ASSOCARBONI

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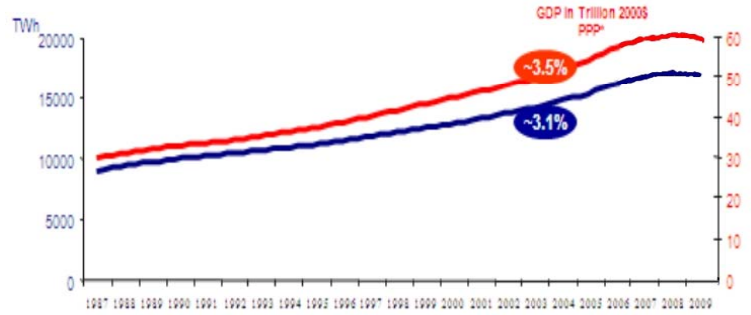
ALSTOM

Key market drivers

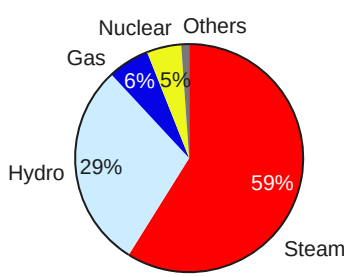
Economic growth
Increase in electricity demand, notably in emerging countries

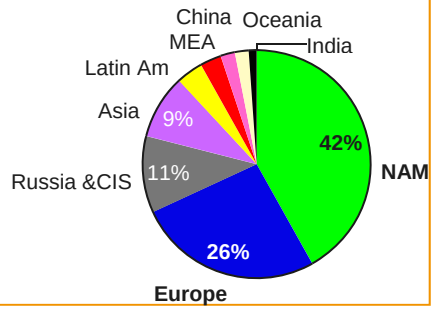
Correlation between electricity consumption and GDP growth



Ageing of power plants
Rising modernisation, service needs and replacement

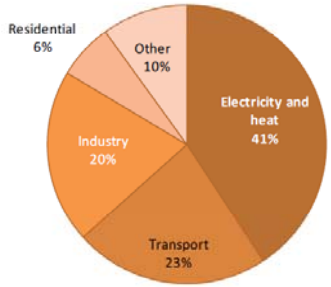
Technological and geographical distribution of >30yr power plants





Environmental regulations
Worldwide awareness of the necessity for emission controls

2009 CO_2 Emissions from fossil fuel combustion

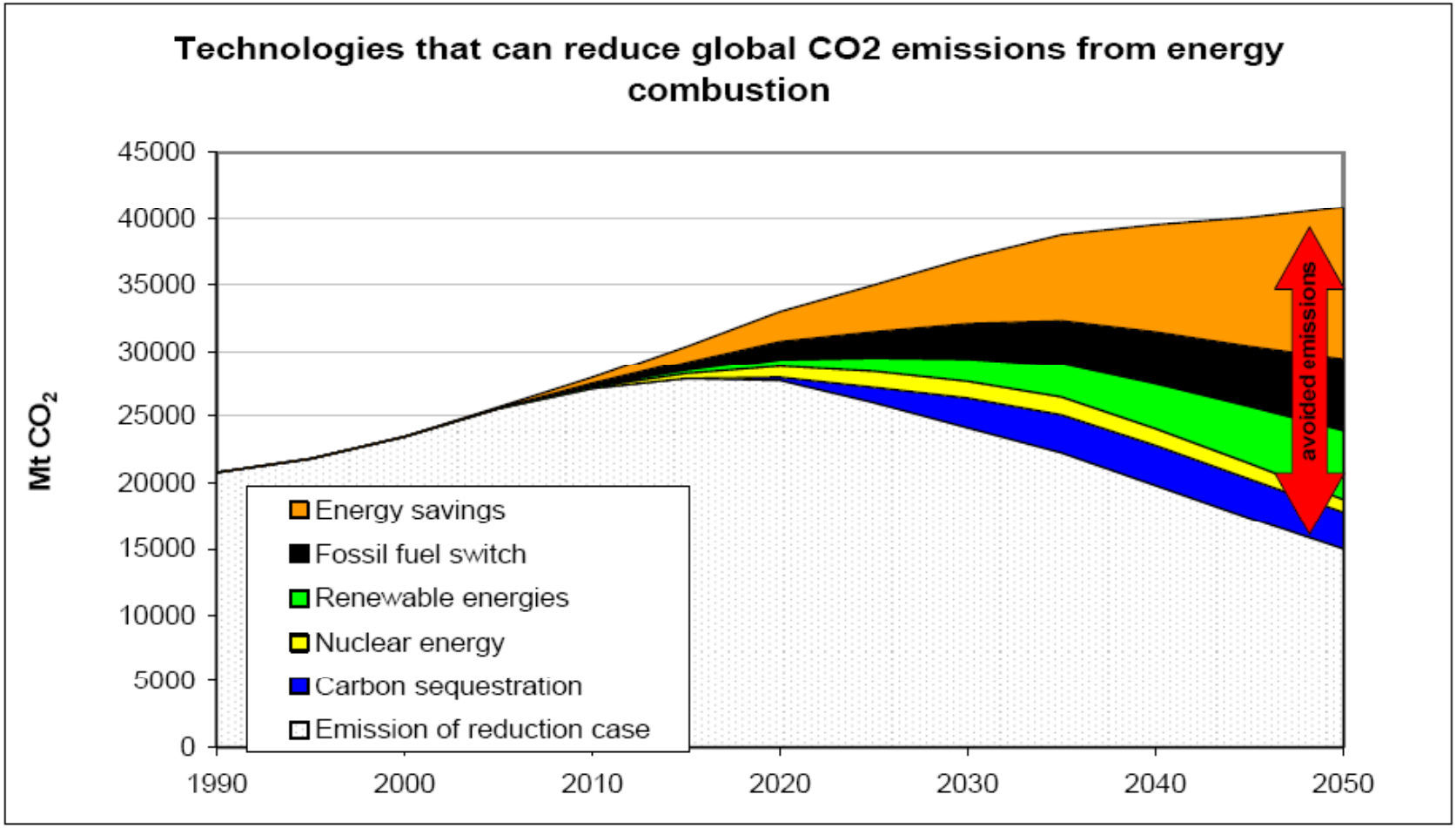


Source: International Energy Agency, Statistics 2011 Ediction

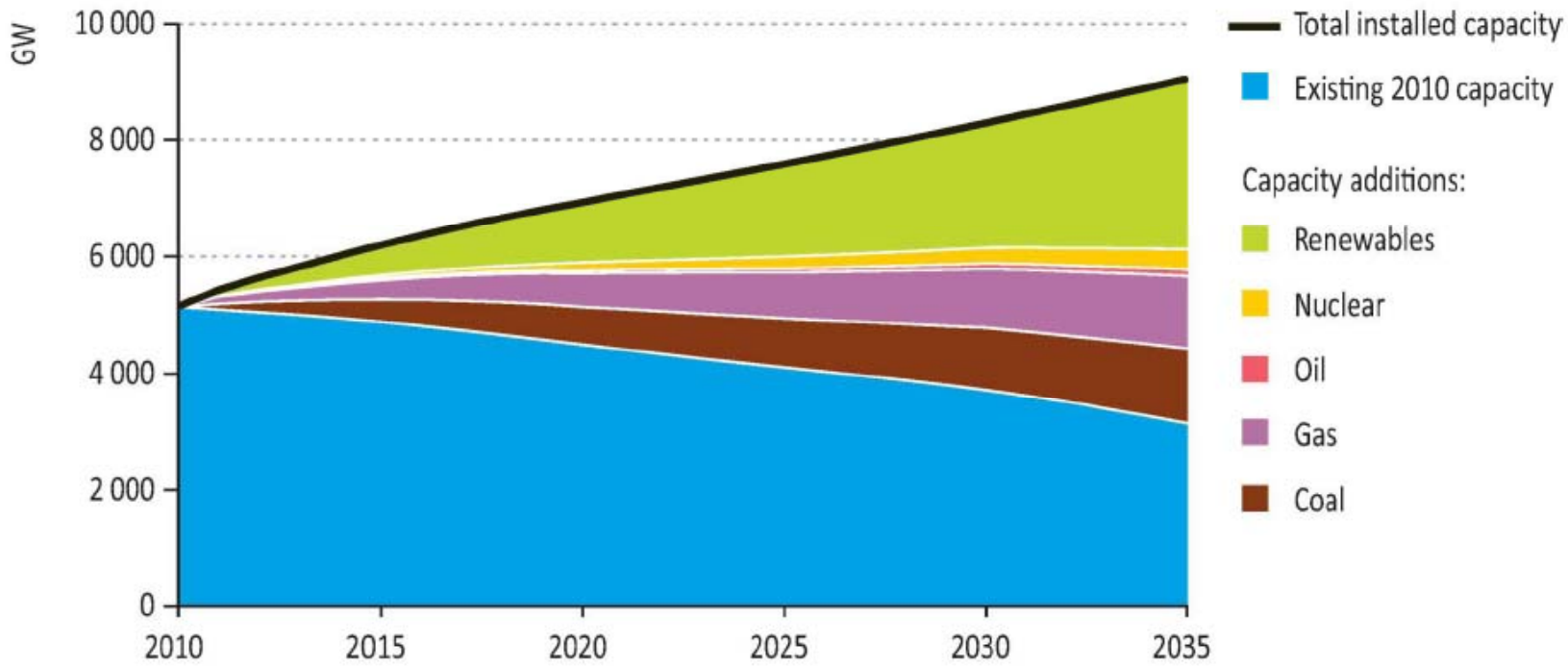
Source: Alstom, IEA/WEO, World Bank, UDI

Emissions reduction is a global need

Source : World Energy Outlook 2011



Installed base (IB) growth by fuel

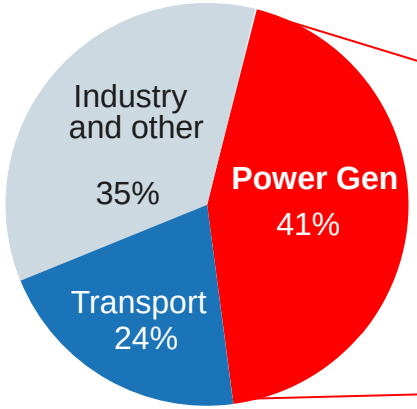


Source : World Energy Outlook 2011

Fuel switch will be filled with Coal and Gas

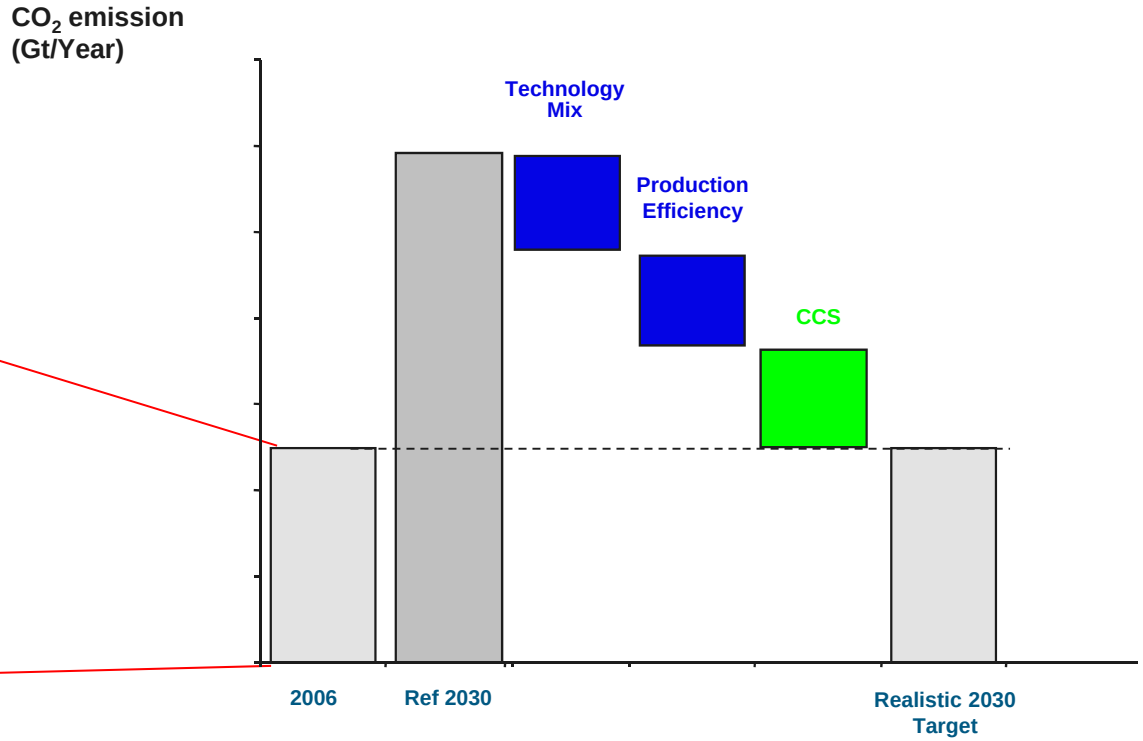
Control Thermal Power Emission by 2030

CO_2 global emissions per sector



Source: International Energy Agency, "World Energy-Related CO_2 Emissions by Sector in the Reference Scenario," **World Energy Outlook 2008**

Power sector-related CO_2 emissions



Source: Power Systems analysis

Power generation is the main CO_2 contributor

Control Thermal Power Emission by 2030

Alstom involvement

- **Technology Mix**
  - Renewable ✓
  - Nuclear (?) ✓

- **Production Efficiency** ✓
  - Retrofits ✓
  - New Power Plants

- **Carbon Capture and Storage** ✓

Source: Power Systems analysis

ALSTOM Technology Mix: Clean Power

Nr.1 in Hydro

Nr. 1 in conventional islands of nuclear power plants

Wind

Nr. 1 in air quality control systems

Strong portfolio of CO_2 free technologies (~1/3 of total portfolio) and promotion of clean combustion

Control Thermal Power Emission by 2030

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Source: Power Systems analysis

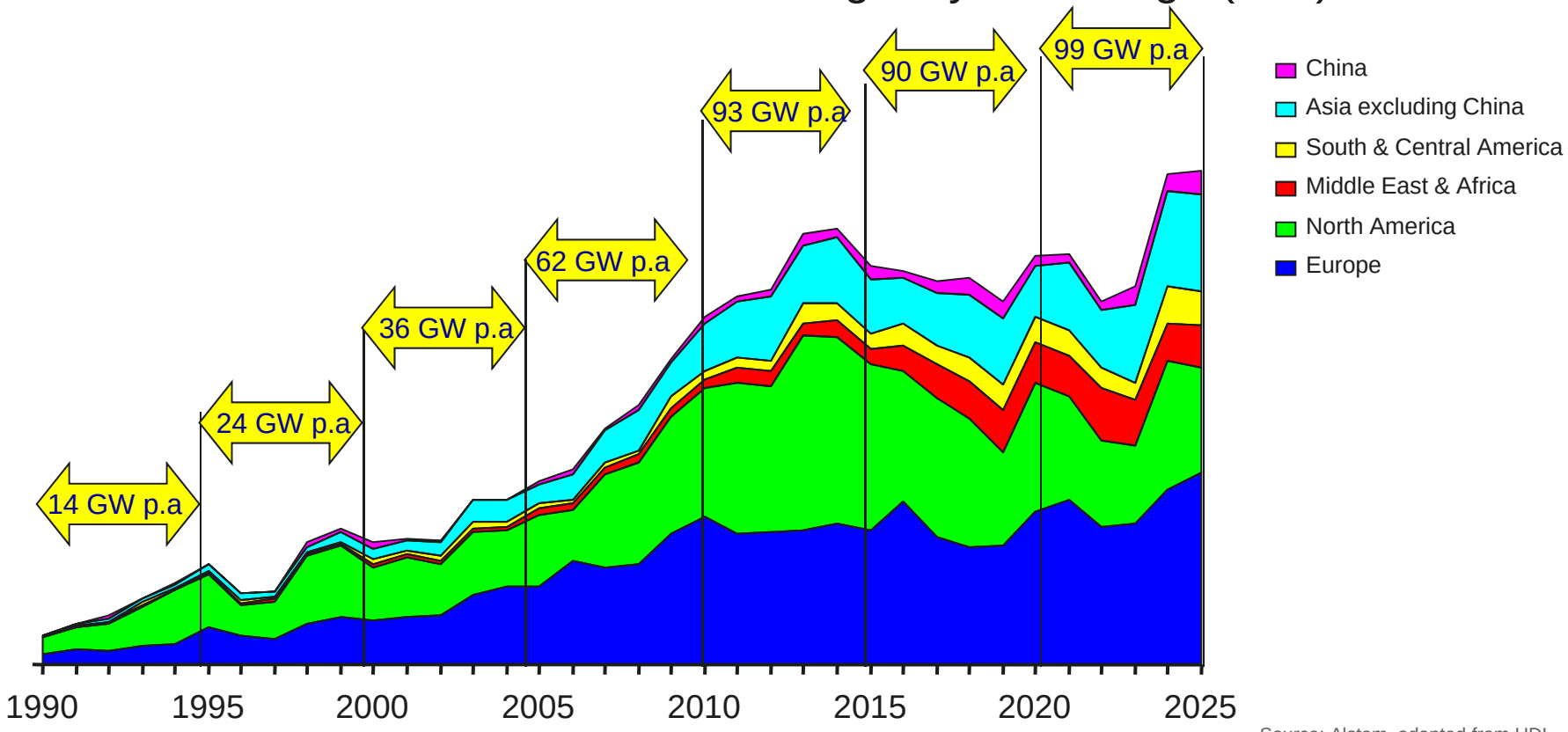
Production Efficiency: New Plants

	Coal	Gas
↗ Efficiency	30% to 50%	40% to 60%
↘ CO_2 emissions	40%	33%

60% of the 2030 installed base still to be built

Ageing fleet curve

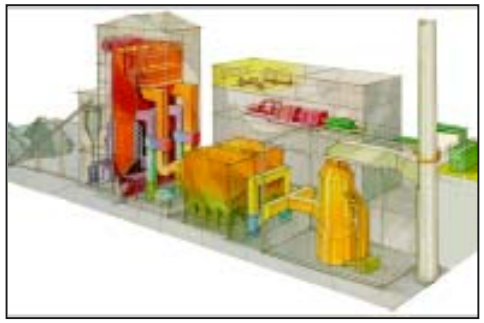
Evolution of installed base reaching 40 years of age (GW)



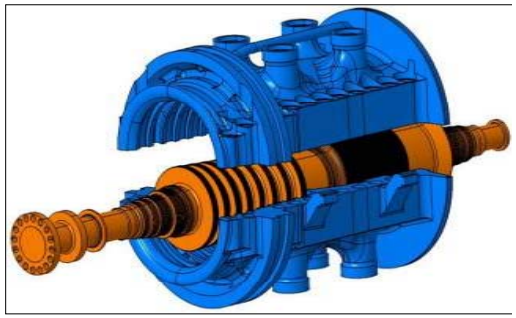
Source: Alstom, adapted from UDI
* Best Available Technology

Replacement and Retrofit with BAT* is a huge opportunity for efficiency

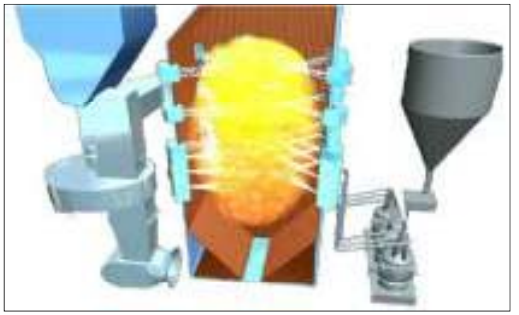
Production efficiency: Retrofit



Plant Optimisation: -5% CO_2



Turbine retrofit: -5% CO_2



Boiler retrofit: -3% CO_2

Retrofit can avoid up to ~13 % CO_2

60% of Carbon emitted in 2030 will come from today's installed base

Control Thermal Power Emission by 2030

Alstom involvement

- **Technology Mix**
  - Renewable ✓
  - Nuclear (?) ✓

- **Production Efficiency**
  - Retrofits ✓
  - New Power Plants ✓

- **Carbon Capture and Storage** ✓

Source: Power Systems analysis

Coal and gas can be clean

Power Plant with CO_2 capture

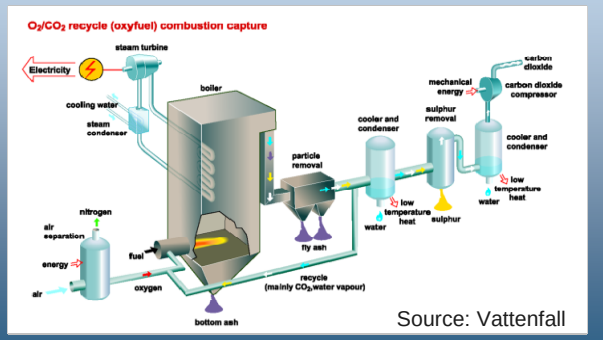
Post-combustion

(New + retrofit)

Source: Vattenfall

Oxy-combustion

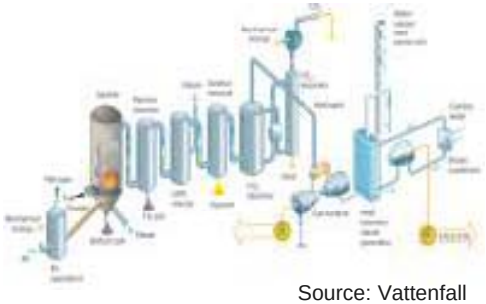
(New + retrofit)



Source: Vattenfall

Pre-combustion

(New only)



Source: Vattenfall

Solutions developed by Alstom

CCS is also applicable on installed base

Alstom activity on 10 major demonstrations

Running / Commissioning

We Energies Pleasant Prairie
USA - 5 MWth
Chilled Ammonia - Coal

Vattenfall Schwarze Pumpe
Germany - 30 MWth
Oxy - Lignite

AEP Mountaineer
USA - 30 MWth
Chilled Ammonia - Coal

EoN Karlshamn
Sweden - 5 MWth
Chilled Ammonia - Fuel/Gas

Total Lacq
France - 30 MWth
Oxy - Gas/Fuel

Statoil Mongstad
Norway - 40 MWth
Chilled Ammonia - Gas

In construction

Industrial pilot
USA/TBA

Advanced Amines

PGE Belchatow
Poland – 20 MWth
Advd. Amines - Lignite

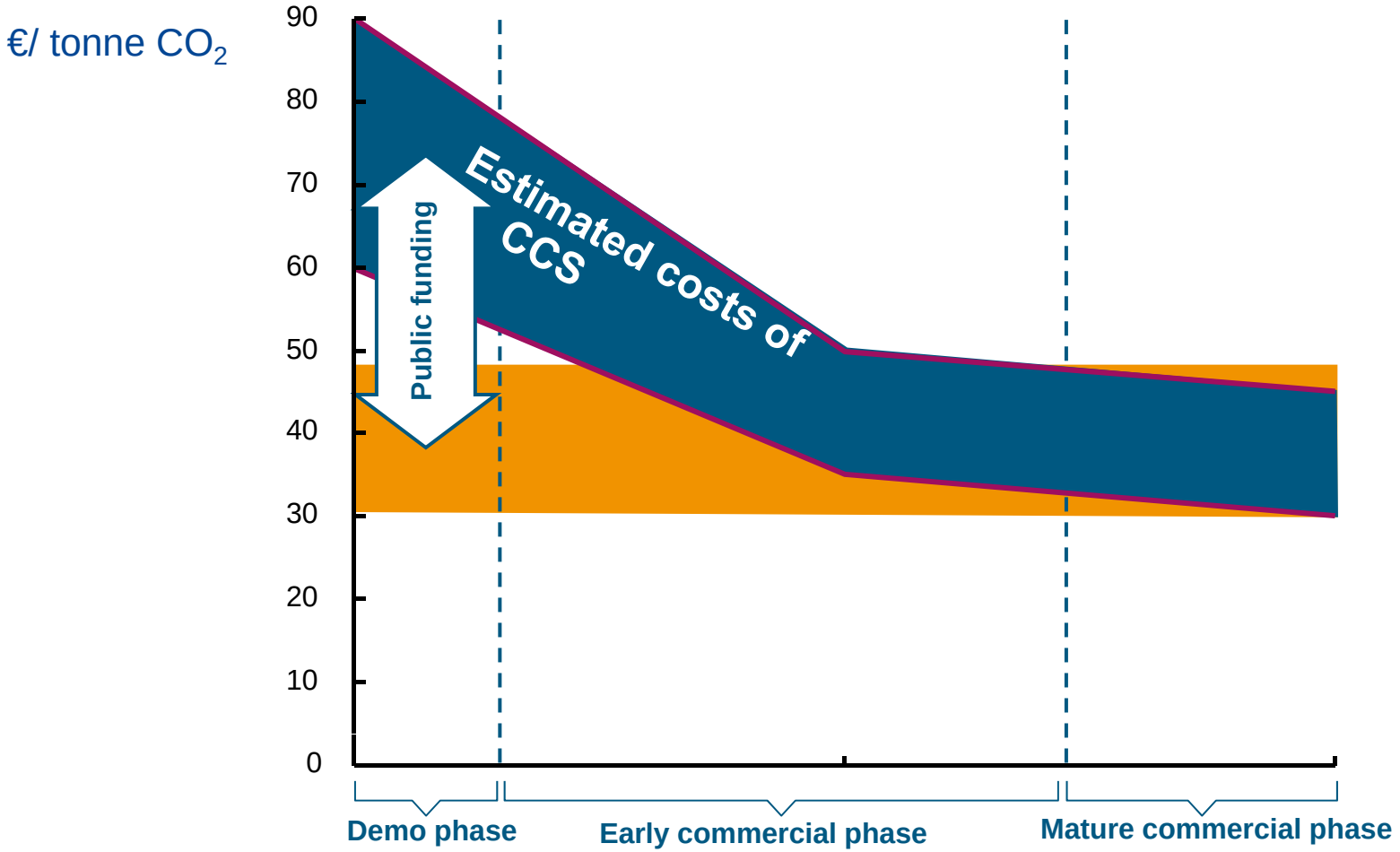
Study / Engineering

Vattenfall Jänschwalde
Germany - 250 MWe
Oxy - Lignite

Transalta
Canada - >200 MWe
Chilled Ammonia - Coal

Source : Alstom

Economics of Carbon Capture and Storage



Source: **McKinsey & Company** "CCS – assessing the economics" for the cost numbers; policy implications drawn by ZEP

Today we provide the cleanest air solutions

- for new plants
- for the installed base