

# CCS – From Pilots to Demos

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Smart Grids & Cleanpower Conference

24/25 June 2010

<http://bit.ly/cleanpower>

**ALSTOM**

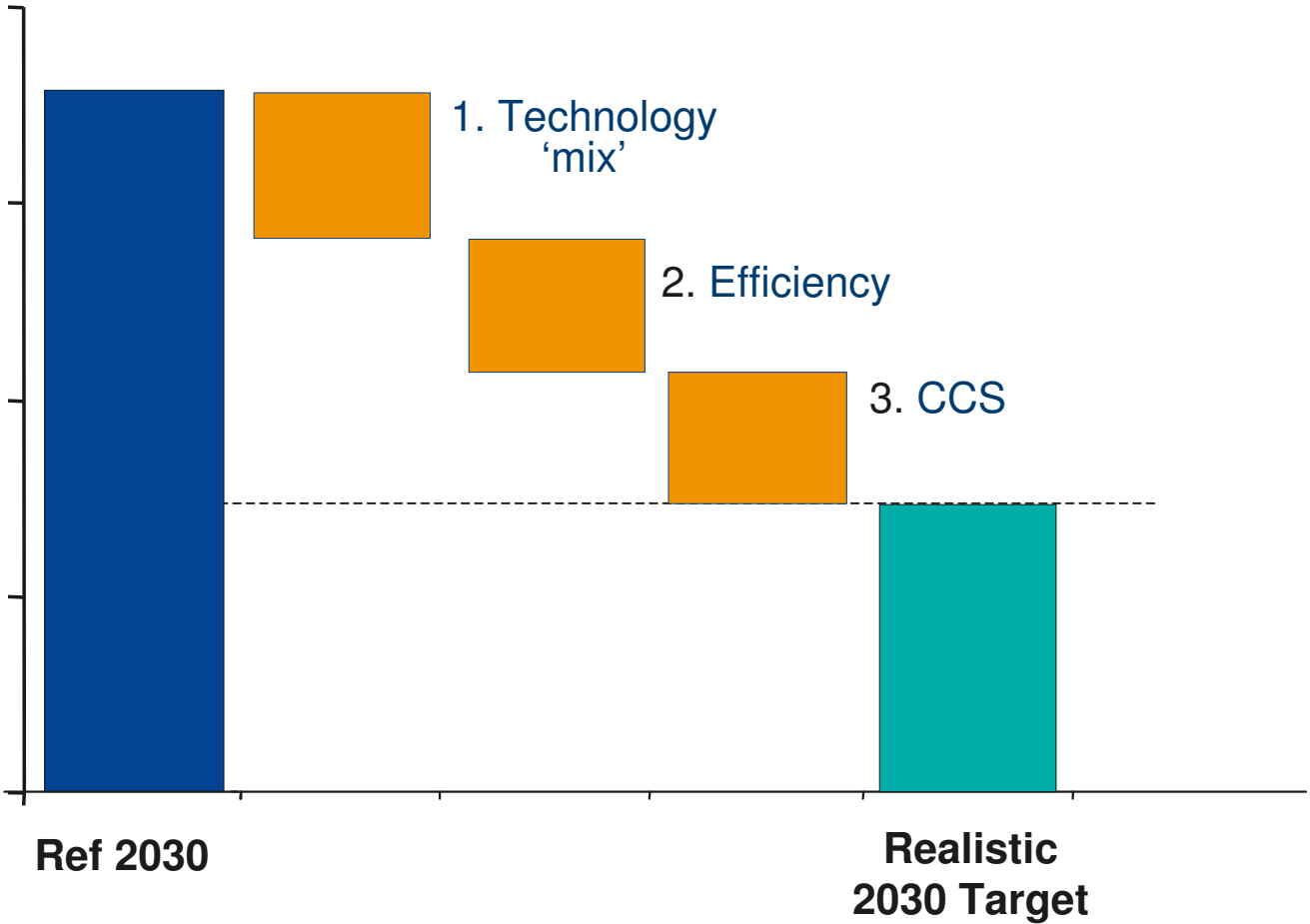
- Context: Alstom's CO<sub>2</sub> strategy
- The challenge of timescale and scale-up
- Alstom's CCS activities
- Closing thoughts...

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# Alstom's CO<sub>2</sub> Strategy: Three Elements



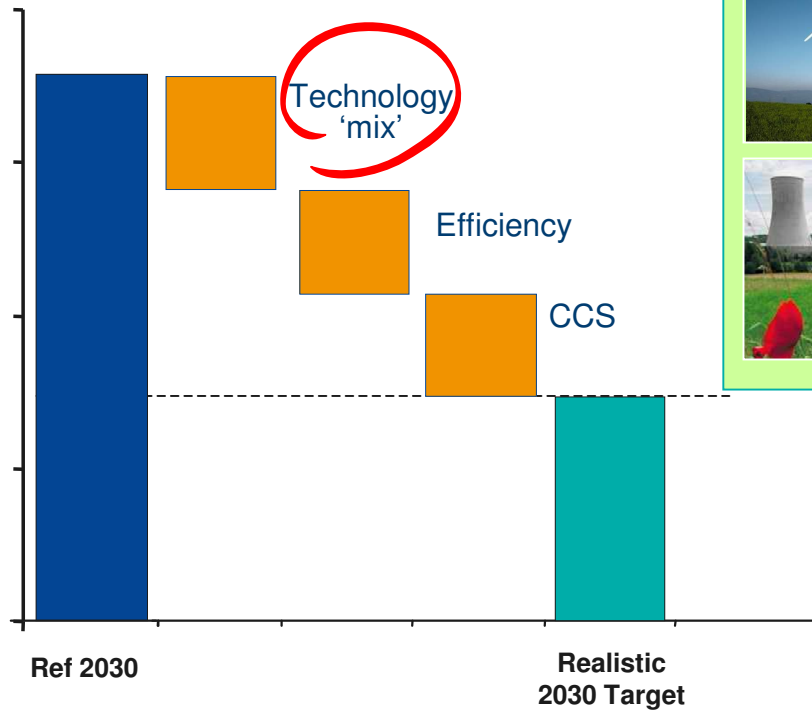
Emissions CO<sub>2</sub>  
(Gt/y)



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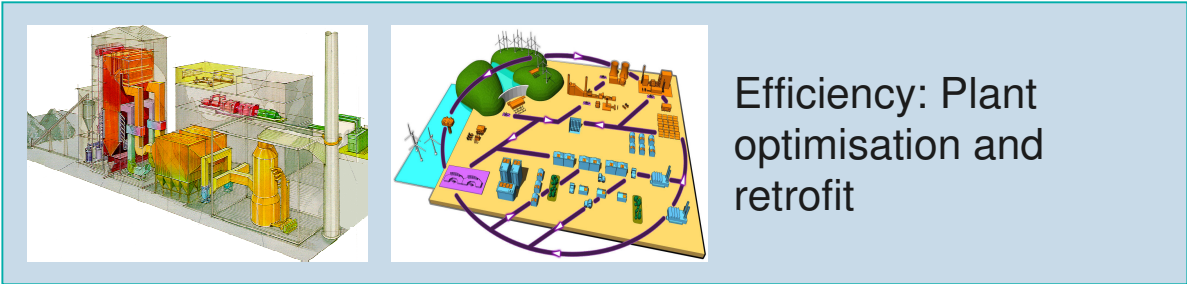
# 1. The Technology 'Mix'

Emissions CO<sub>2</sub>  
(Gt/y)



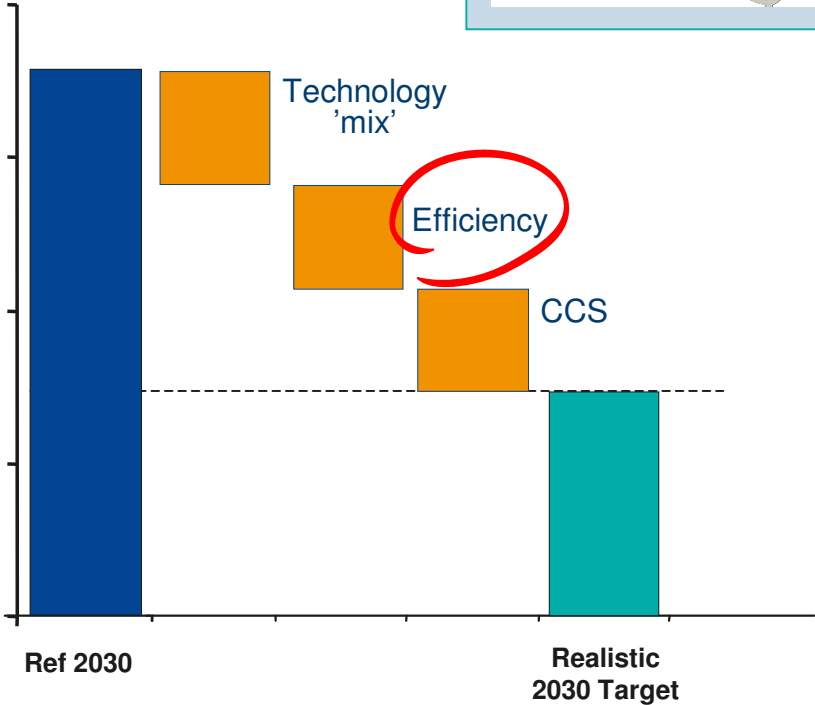
- N° 1 hydro  
Tidal
- Wind and  
geothermal
- N° 1 nuclear  
(conventional  
islands)  
and biomass

# 2. Generation Efficiency



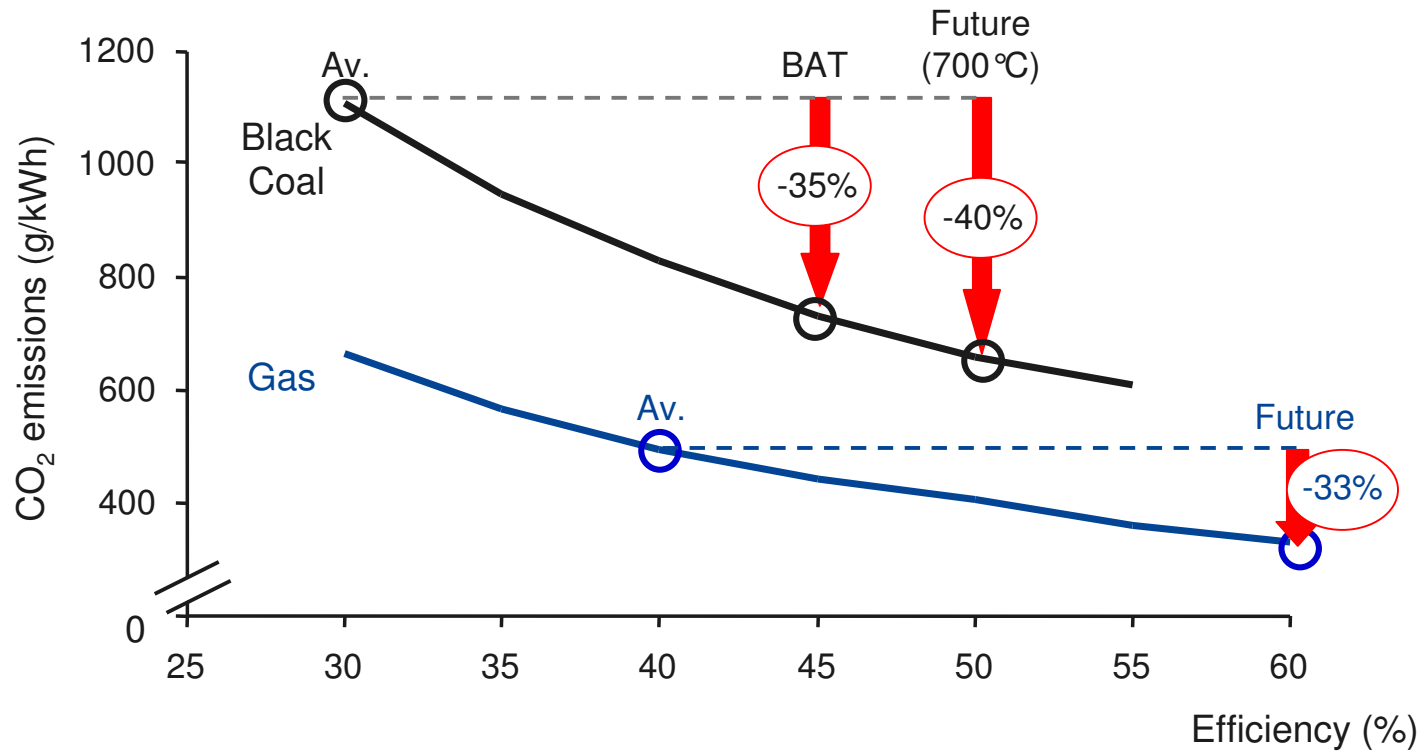
Efficiency: Plant optimisation and retrofit

Emissions CO<sub>2</sub> (Gt/y)



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# Impact of Efficiency on CO<sub>2</sub> Emissions



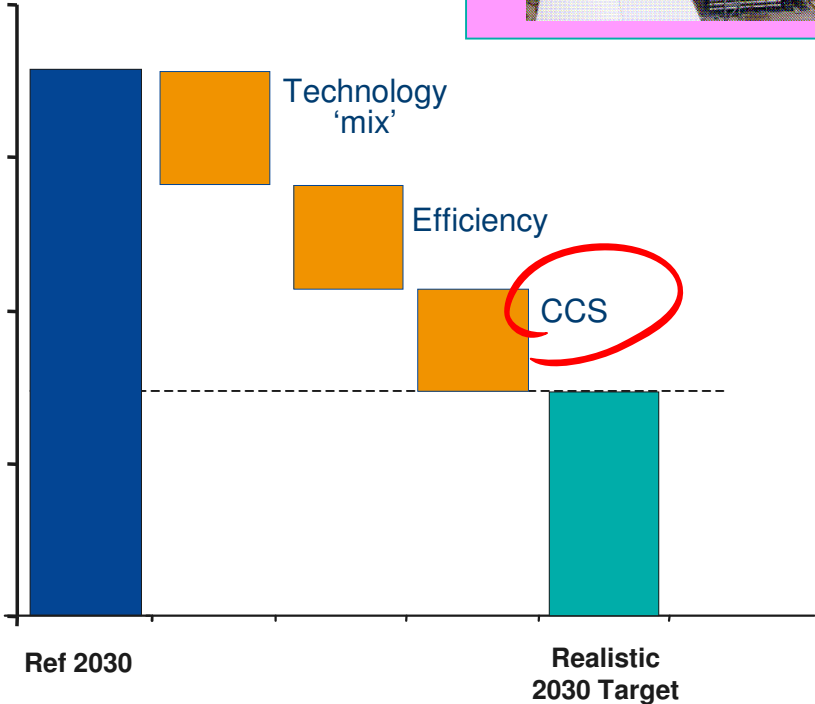
Source: Alstom

	↗ Efficiency	↘ CO <sub>2</sub> emissions
• Coal:	30% to 50%	40%
• Gas:	40% to 60%	33%

# 3. CO<sub>2</sub> Capture and Storage



Emissions CO<sub>2</sub> (Gt/y)



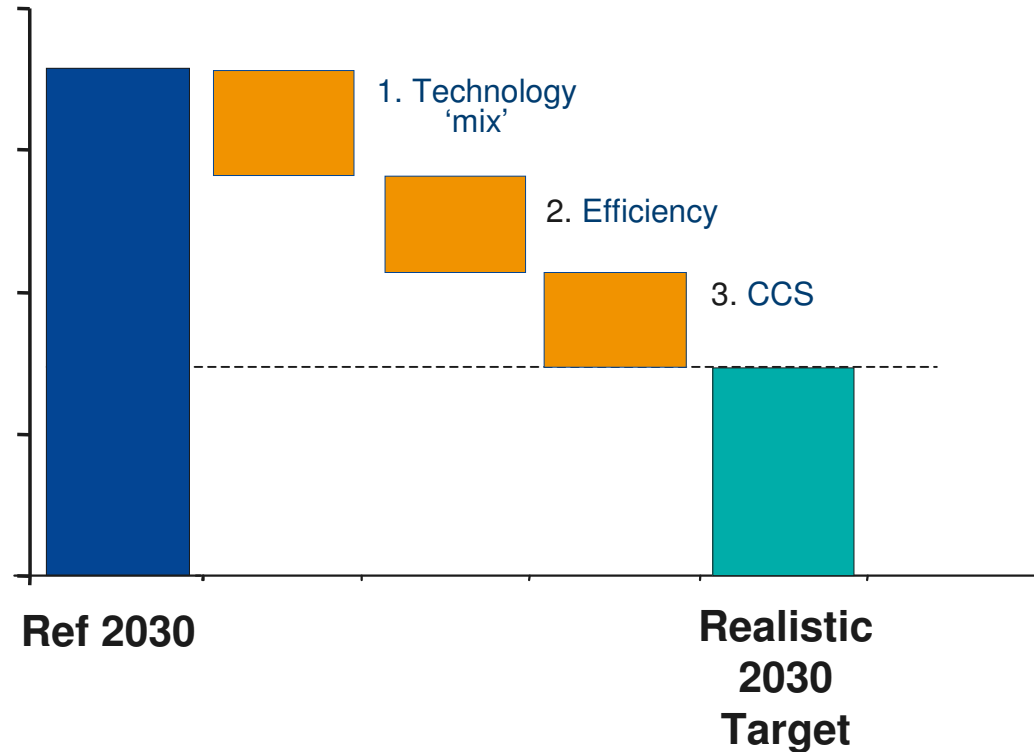
Leader in CO<sub>2</sub> capture technology



# Alstom's CO<sub>2</sub> Strategy



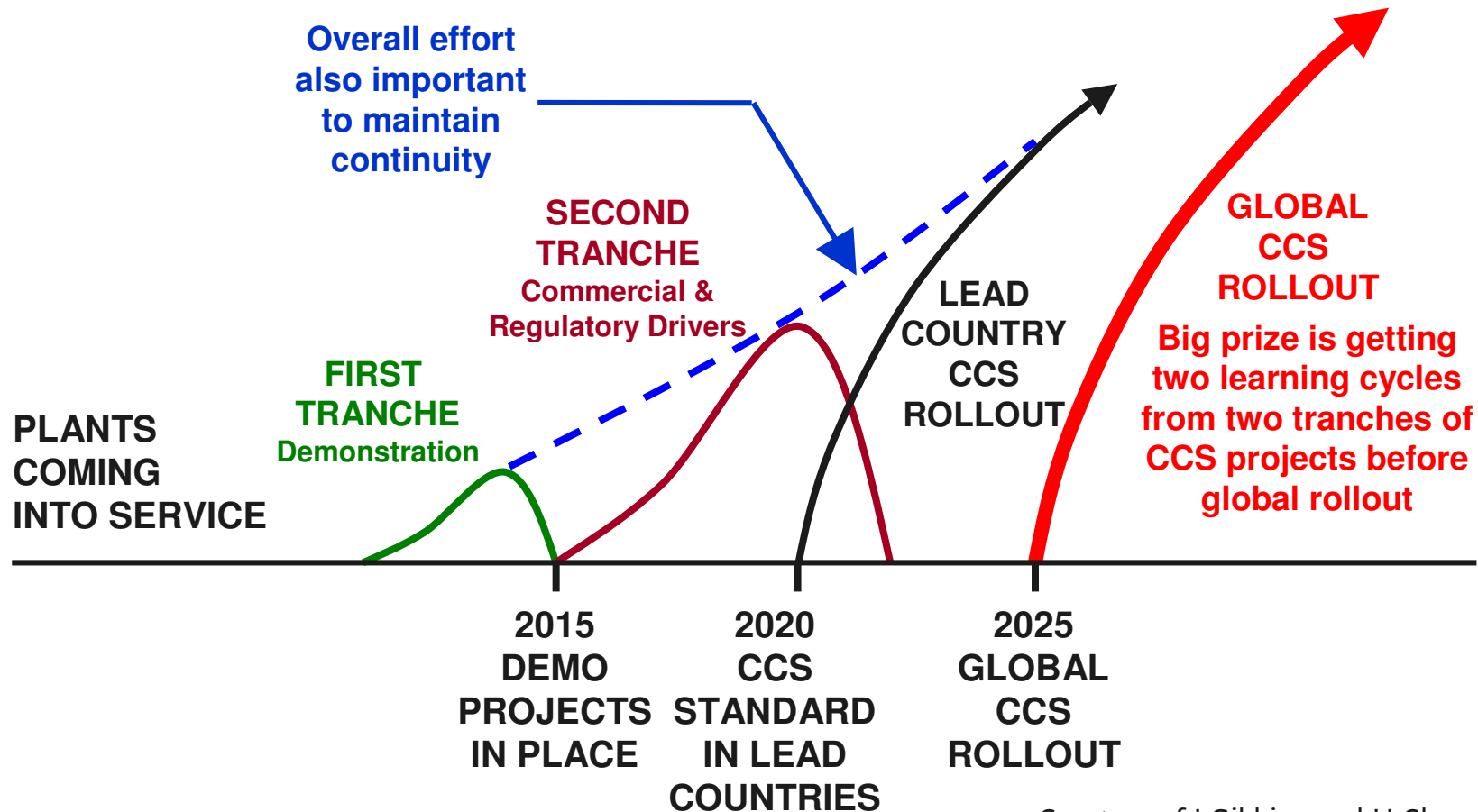
Emissions CO<sub>2</sub>  
(Gt/y)



We need all three elements of this strategy.....

- Context: Alstom's CO<sub>2</sub> strategy
- The challenges of timescale and scale-up
- Alstom's CCS activities
- Closing thoughts...

# Demos – Why the Short Timescale?



Courtesy of J Gibbins and H Chambers  
University of Edinburgh

# 30MW<sub>th</sub> Oxy-fuel Combustion Pilot Plant at Vattenfall's Schwarze Pumpe Power Station

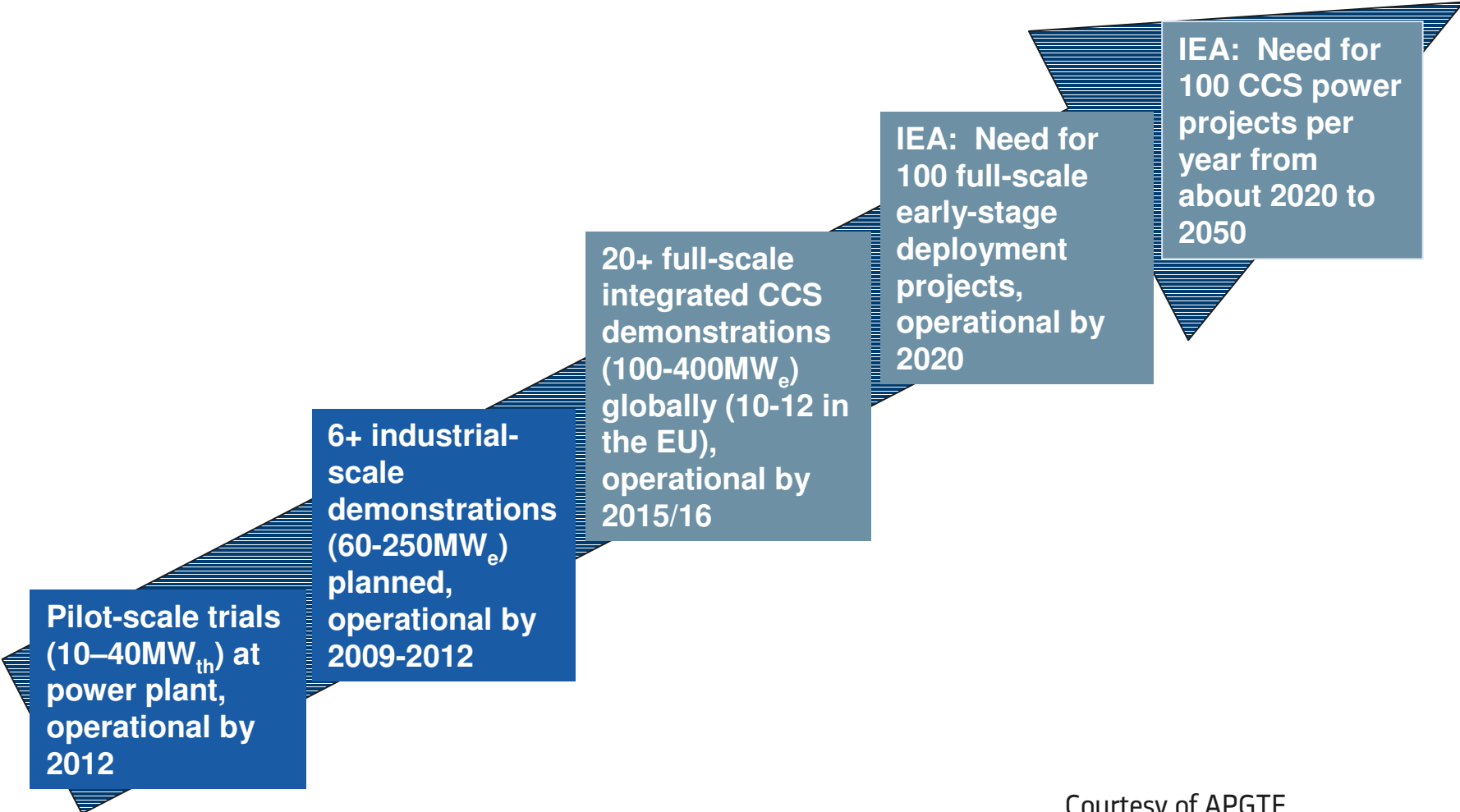




# 30MW<sub>th</sub> Oxy-fuel Combustion Pilot Plant at Vattenfall's Schwarze Pumpe Power Station

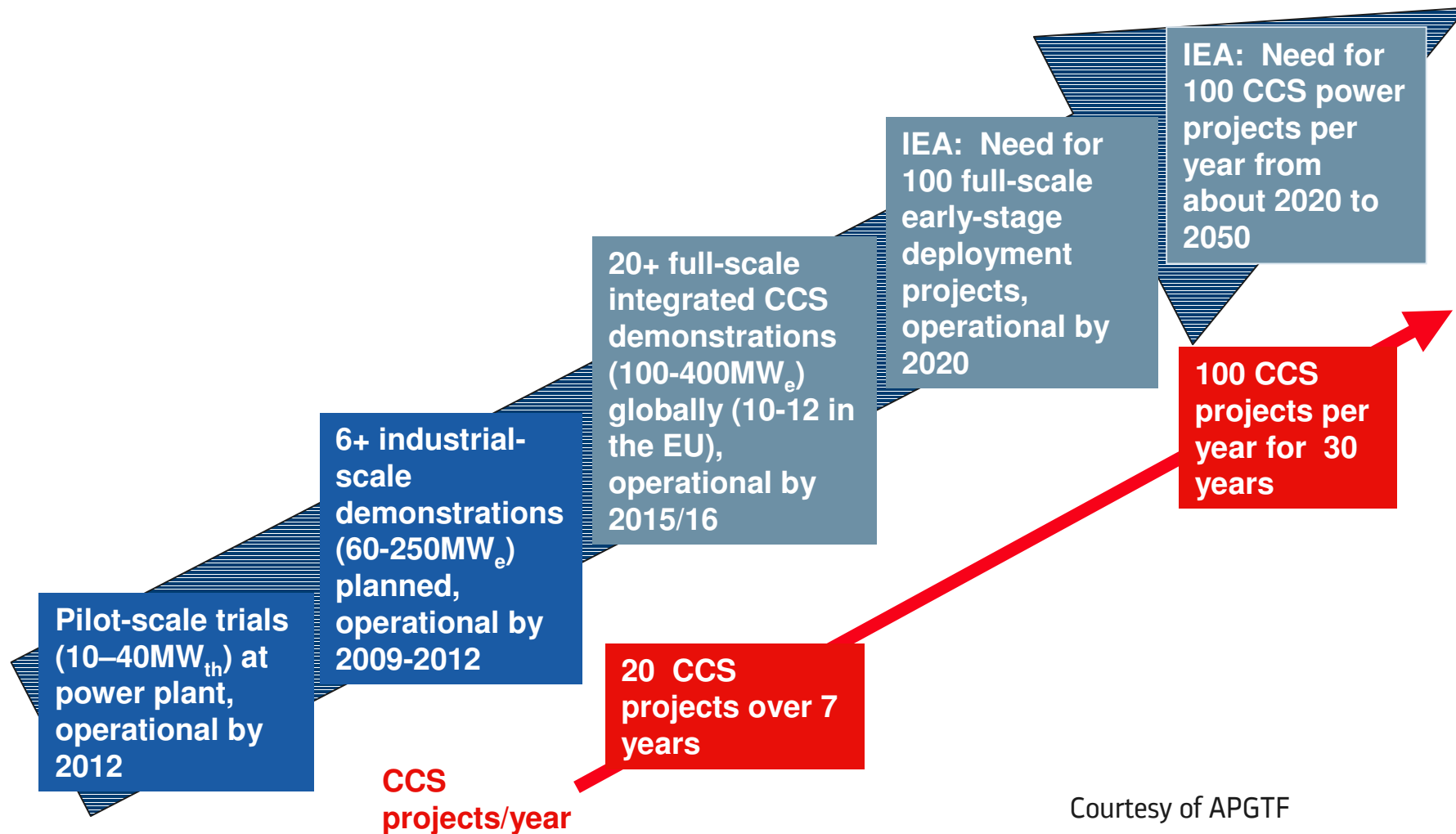


# The BIG Challenge – Scale-up of CCS Capacity for Commercialisation



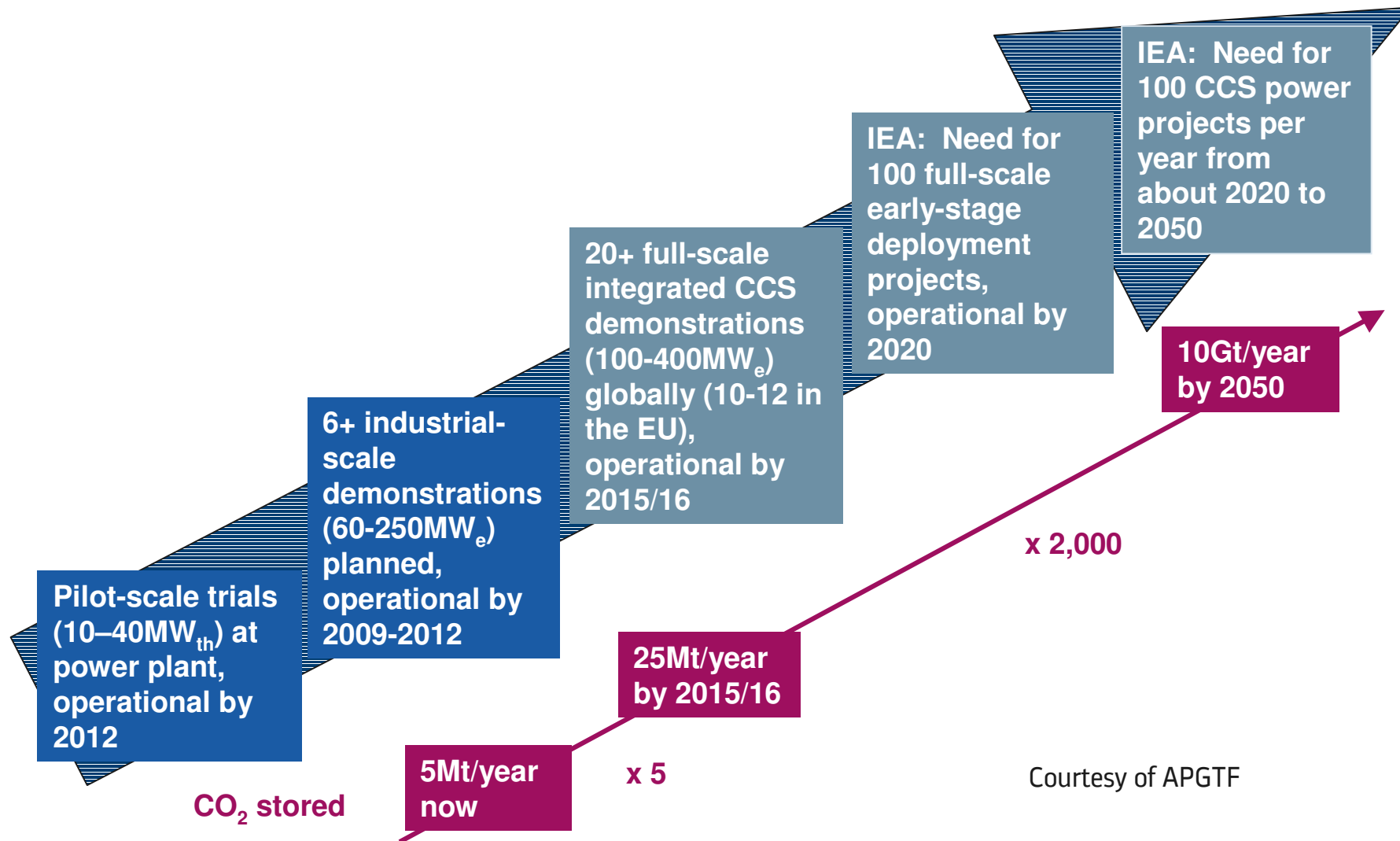
Courtesy of APGTF

# The BIG Challenge – Scale-up of CCS Capacity for Commercialisation



Courtesy of APGTF

# The BIG Challenge – Scale-up of CCS Capacity for Commercialisation



Courtesy of APGTF



- Context: Alstom's CO<sub>2</sub> strategy
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# CO<sub>2</sub> Capture Solutions within Alstom



## Power Plant with CO<sub>2</sub> capture

Post-combustion  
(New + retrofit)



- Chilled Ammonia
- Advanced Amines

Solutions developed by Alstom

Oxy-combustion  
(New + retrofit)



Pre-combustion  
(New only)



Source: Vattenfall

## CCS must be also applied to the installed base

# Main Partnerships and Projects Portfolio



Advanced Amines	Joint development programme West Virginia Pilot (USA) - <b>Coal</b>		
	Belchatow (Poland) – <b>Lignite</b>	>250 MWe	
	Archer Daniels Midland (USA) – <b>Coal</b>		
Chilled Ammonia	Pleasant Prairie (US) – <b>Coal</b>	5 MWt	
	Karlshamm (Sweden) – <b>Oil/Gas</b>	5 MWt	
	Montainer (US) – <b>Coal</b>	58 MWt	
	Mongstad (Norway) – <b>Gas</b>	40 MWt	
	Mountaineer (US) – <b>Coal</b>	235 MWe	
	TransAlta (Canada) – <b>Coal</b>	200 MWe	
	Oxy-combustion	Schwarze Pumpe (Germany) – <b>Lignite</b>	30 MWt
Lacq (France) – <b>Gas</b>		30 MWt	
Alstom Boiler Simulation Facility Windsor (US) – <b>Coals</b>		15 MWt	
Jänschwalde (Germany) – <b>Lignite</b>		250 Mwe (Feasibility study)	

6 Pilots in commissioning/operation

Tests completed

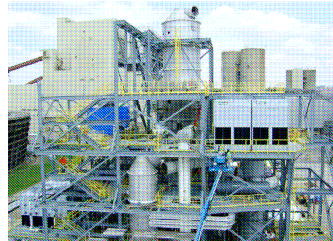
# Alstom – 12 Major Pilots/Demonstrations



## Operating



**Vattenfall Schwarze Pumpe**  
Germany - 30 MWth  
Oxy - Lignite



**AEP Mountaineer**  
USA - 58 MWth  
Chilled Ammonia - Coal



**EoN Karlshamn**  
Sweden - 5 MWth  
Chilled Ammonia - Fuel



**Total Lacq**  
France - 30 MWth  
Oxy - Gas



**Dow Chemical Co.**  
USA, West Virginia  
Advanced Amines - Coal



**Alstom BSF Windsor**  
US - 15 MWth  
Oxy - Coals

## Coming



**PGE Belchatow**  
Poland – 260 MWe  
Adv. Amines - Lignite



**Vattenfall Jämschwale**  
Germany - 250 MWe  
Oxy - Lignite



**Statoil Mongstad**  
Norway - 40 MWth  
Chilled Ammonia - Gas



**Transalta**  
Canada - >200 MWe  
Chilled Ammonia - Coal



**Archer Daniels Midland**  
USA, Illinois  
Advanced Amines - Coal



**AEP Mountaineer**  
USA – 235MWe  
Chilled Ammonia - Coal

 Selected for receiving EEPR funding

 Selected by Alberta and Federal Canadian funding

 Selected by US DOE to receive CCPI Round 3 funding

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# Advanced Amine Process

## Field Pilot Testing at Charleston, USA



### Industrial Pilot Programme

- Designed to capture 1,800tCO<sub>2</sub>/year
  - Installation on commercial coal-fired boiler
- Project schedule:
  - Commissioned July 2009
  - Testing started Autumn 2009 (initial configuration)
  - Conversion to advanced configuration early 2010 to test proprietary process jointly developed by Dow and Alstom
- Testing to continue into 2011



# Advanced Amine Process

Planned Demo Facility at Belchatow, Poland



## Technology Demonstration Programme

- MOU between Alstom and PGE Elektrownia Belchatow, for large CCS facility:
  - Host facility 850MW lignite unit under construction
  - 1.8+MtCO<sub>2</sub>/year
  - Detailed engineering started January 2010
  - Operational in end 2014/early 2015



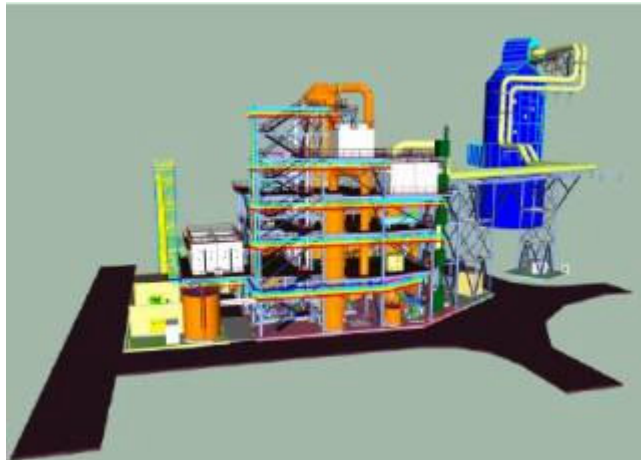
Selected for receiving EEPR funding

# Chilled Ammonia Process

## Product Validation Facility at AEP Mountaineer, USA



Product Validation Facility



### Technology Validation Programme

- Designed to capture and store 100,000tCO<sub>2</sub>/year
- Captured CO<sub>2</sub> will be stored in two wells on the plant property
- Commenced engineering and permitting in Oct 2007
- Started construction 2Q 2008
- Project start-up Sept 2009
- Alstom responsible for CAP island, AEP responsible for utilities to/from CAP island and CO<sub>2</sub> storage (Battelle as contractor)

# Chilled Ammonia Process

Planned Demo Facility at AEP Mountaineer, USA



**Mountaineer Power Plant**

## Technology Demonstration Programme

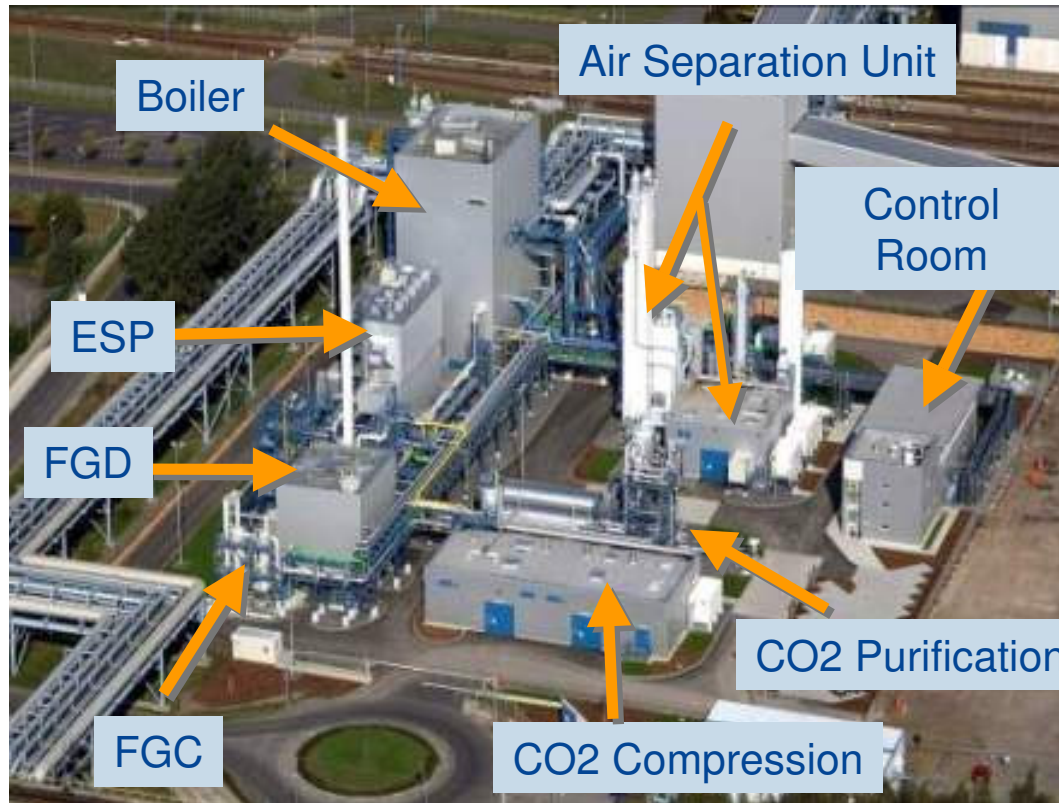
- Host facility same as Product Validation Facility currently operating
- Larger facility, designed to capture and store 1.5Mt CO<sub>2</sub>/year
- Project selected by US DOE to receive CCPI Round 3 funding under the American Recovery and Reinvestment Act
  - Total funding of \$334M
- Project to start operation in 2015

**Selected by US DOE to receive CCPI Round 3 funding**



# Oxy-fuel Combustion

Pilot Plant at Vattenfall Schwarze Pumpe, Germany



(source: Vattenfall)



## Pilot Plant Programme

### Goal

- Validation of oxy-fuel process, (started Sept 08)

### Main features

- Oxy-PC Boiler 30 MW<sub>th</sub> 40t/h
- Coal 5,2 t/h **lignite**
- Cycle 25b/330 °C
- Oxygen 215 t/day
- CO<sub>2</sub> 9 t/hr
- Alstom scope: oxy-boiler and ESP

# Oxy-fuel Combustion

Planned Demo Facility at Vattenfall Jaenschwalde, Germany



(source: Vattenfall)

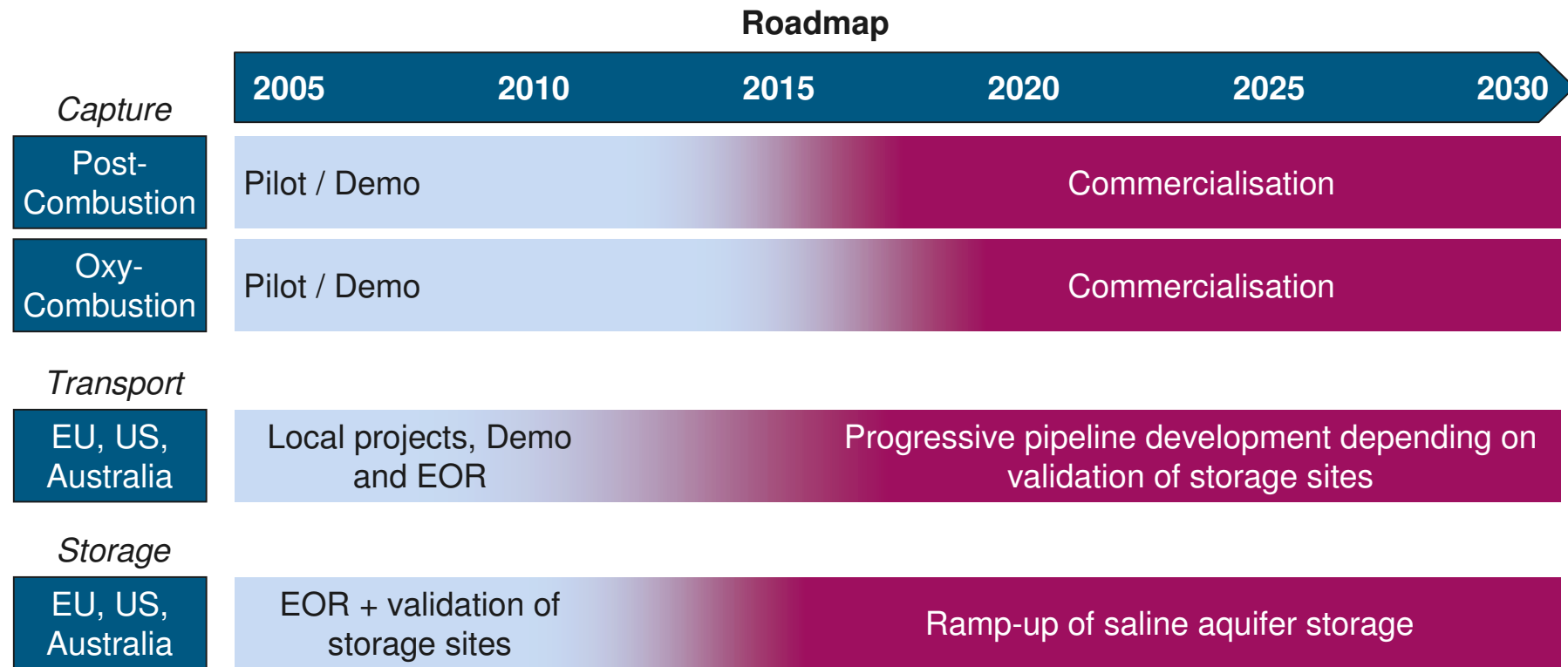


## Main features

- Existing plant, oxy on 250 MWe eq. gross
- Location: 100 km SE of Berlin
- New oxy-PC tower boiler 815t/h
- SH/RH 535/540 °C, 165/40b
- Lignite fuel
- Feasibility study completed April 2009 for oxy-boiler and subsequent FG cleaning

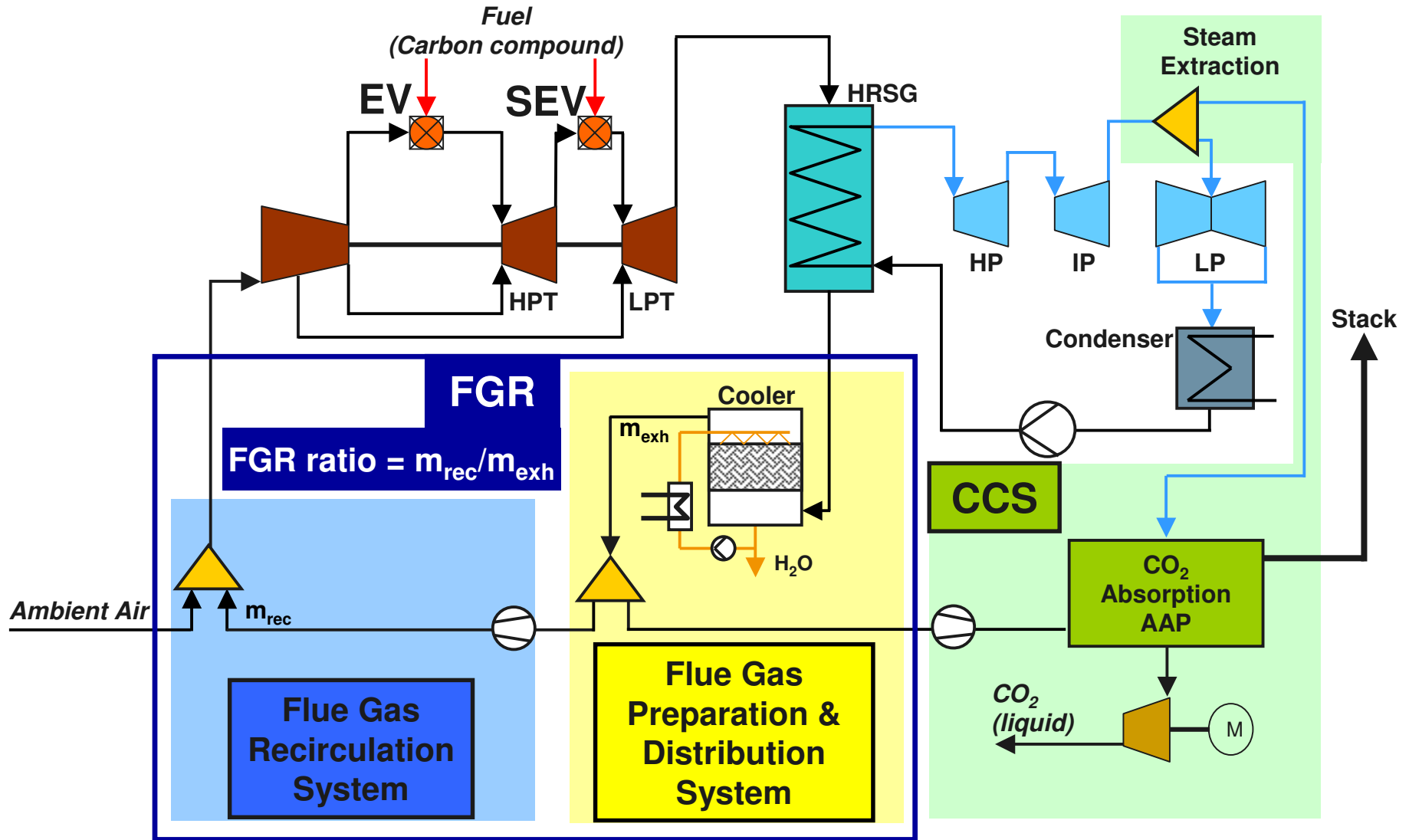
Selected for receiving EPR funding

# CCS Roadmap



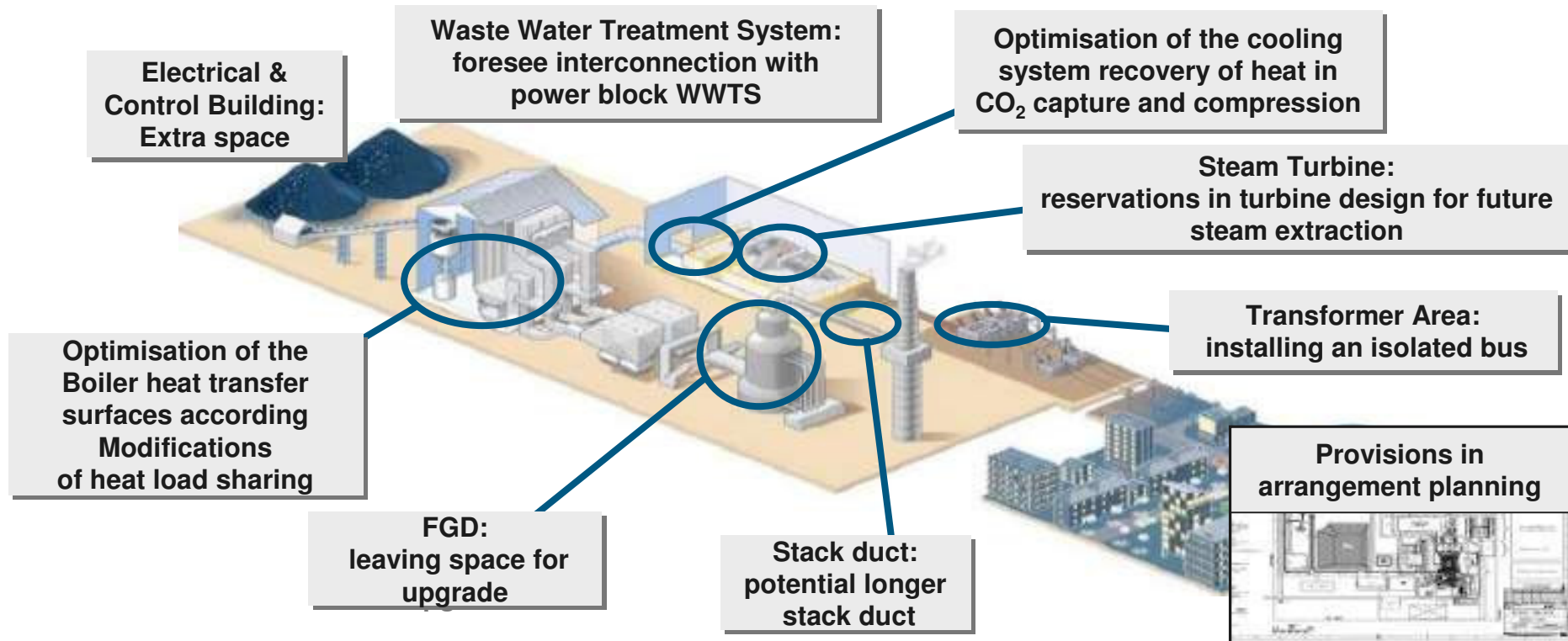
**Market and technology development require large-scale demos**

# GT with Flue Gas Recirculation (FGR)



# Capture-Ready Study

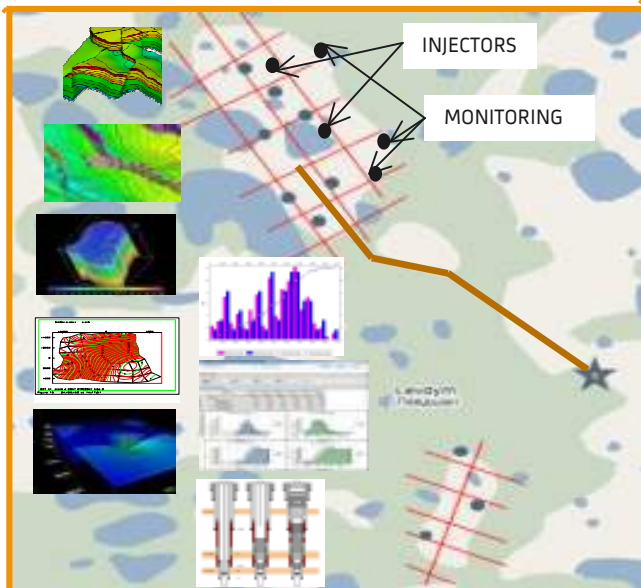
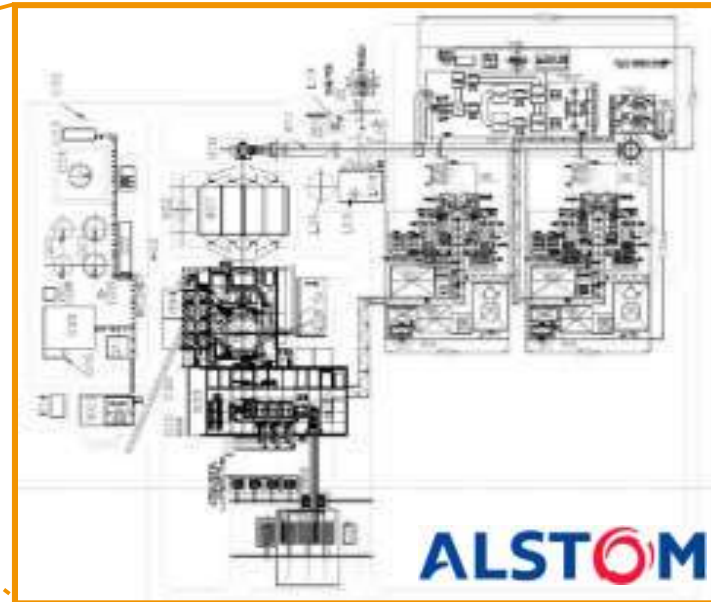
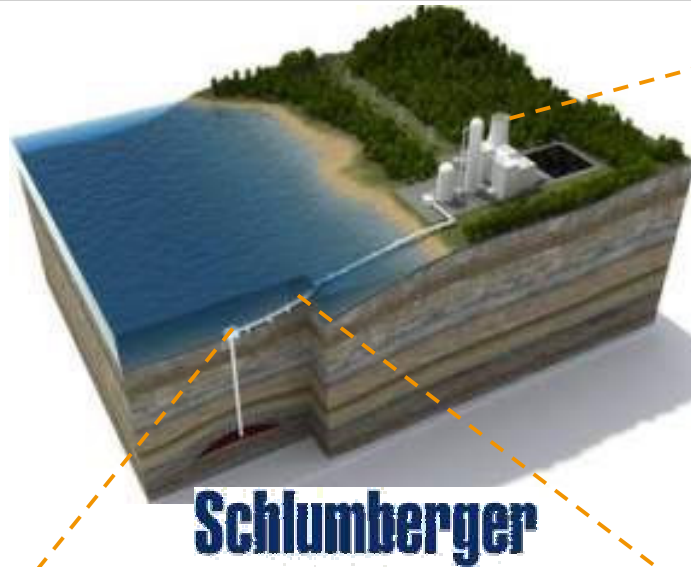
## Identified pre-investments (coal example)



### Alstom Capture-Ready solutions developed upon three pillars:

- **Early and substantial investment in capture technologies development**
- **Integrated power plant expertise** (EPC supplier of turnkey power plant)
- **Component supplier experience** (supplier of a major equipment in 25% of the worldwide installed power capacity)





Combining expertise to address entire CO<sub>2</sub> capture, transport and storage chain

- Context: Alstom's CO<sub>2</sub> strategy
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- Portfolio approach needed to address CO<sub>2</sub> challenge: demand reduction; new technology/fuel mix (renewables, nuclear); increased generation efficiency; and CCS
- Scale-up challenge of CCS (number, timescale) huge
- Demos are URGENT – not just on coal but also gas
- ‘CCS-readiness’ also important
- Public acceptance of CCS could well be ‘show-stopper’
- Developing countries key

Alstom looking at be a key partner for complete CCS value chain



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