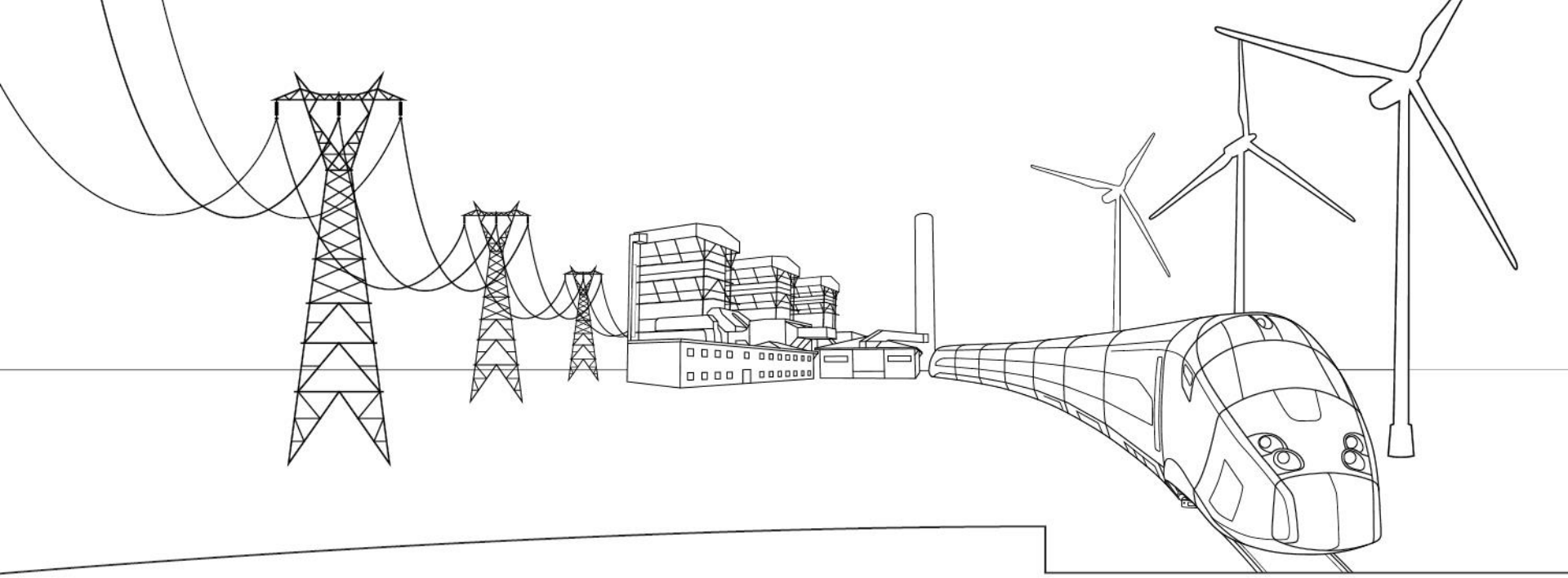

The way forward for CCS in Poland

Giles Dickson, VP Global Public Affairs

18 November 2014

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Shaping the future

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Alstom Thermal Power

Alstom Grid

Alstom Renewable Power

Alstom Transport

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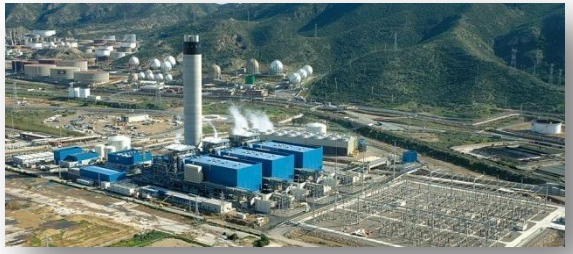
Alstom: Technology for Power Generation

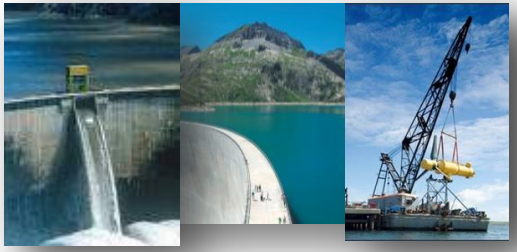
Gas



Coal

Oil

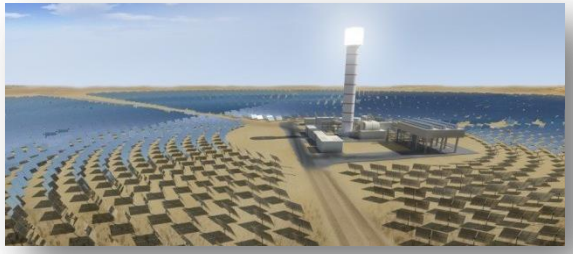
Hydro,Storage,Ocean



Nuclear (turbine island)

Wind on and offshore

Solar



Geothermal

Biomass

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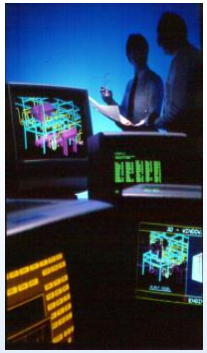
Alstom CCS offering



Concept > **Engineering** > **Construction** > **Commissioning**

- Technology Expertise
- Feasibility Study (+30/-30%)
- Basic Engineering (+20/-20%)
- Authority Engineering
- Financial Engineering

- Project Management
- FEED (+/-10%)
- HAZOP Study
- Detail Engineering
- Procurement
- Scheduling
- Cost Control

- Construction Management
- Construction Supervision
- Safety
- Quality Control
- Schedule & Cost Control
- Field Engineering
- As-Built-Documentation

- Pre-Commissioning
- Commissioning
- Training of Operators
- Training of Maintenance Crews

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Alstom CO2 capture technologies

Post-combustion

(New + retrofit)

- Advanced Amines
- Chilled Ammonia

2nd Generation

Regenerative Calcium Cycle

Oxy-combustion

(New + retrofit)

- Oxy-combustion with ASU

2nd Generation

Chemical Looping

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From pilots to full-scale demonstration

TESTS COMPLETE

AEP Mountaineer
USA – 58 MWth
Chilled Ammonia, Coal

Vattenfall Schwarze Pumpe, Germany
30 MWth, Oxy - Lignite

EoN Karlshamn
Sweden - 5 MWth
Chilled Ammonia, Fuel

Total Lacq
France - 30 MWth
Oxy - Gas

WE - Energie
USA WI - 5 MWth
Chilled Ammonia, Coal

DOW Chemical Co.
USA, WV
Adv. Amines - Coal

EDF Le Havre
France - 5 MWth Adv.
Adv. Amines - Coal

TCM Mongstad Norway
40 MWth, Chilled Ammonia,
CHP & Refinery Offgas (RCC)

OPERATING

Alstom BSF Windsor
US - 15 MWth
Oxy - Coals

Alstom GPU Pilot (Mobile)
0.3 MWth

Alstom Labs Växjö
Sweden – 0.25 MWth
Post C.-multi purpose

COORETEC DE, FP7 EU - Darmstadt
Germany - 1 MWth
Regenerative Calcium Cycle - Coal

DOE/Alstom Windsor
US - 3 MWth
Chemical Looping, Coal

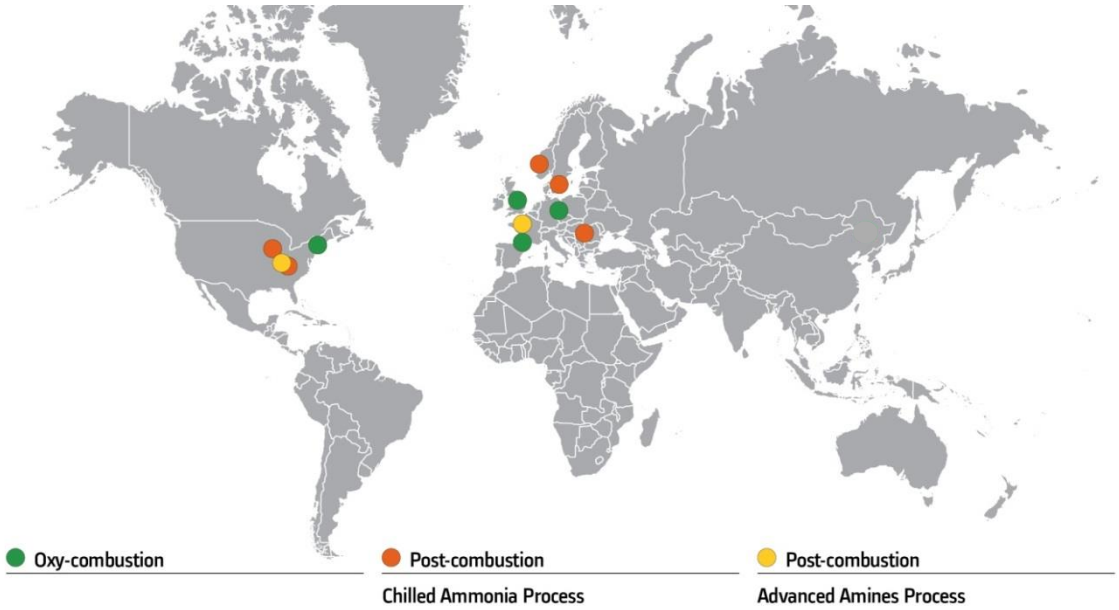
RFCS EU - Darmstadt
Germany - 1 MWth
Chemical Looping - Coal

LARGE-SCALE PROJECTS (under development)

White Rose CCS Project
UK - 426 MWe
Oxy Hardcoal

FINAL INVESTMENT DECISION: end-2015

Our CCS Partnerships



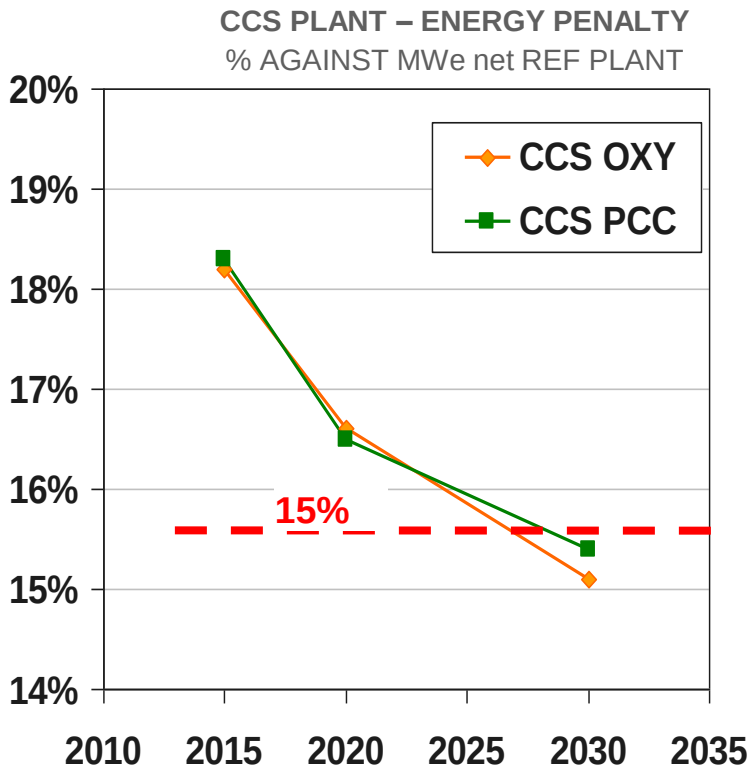
Global collaborations

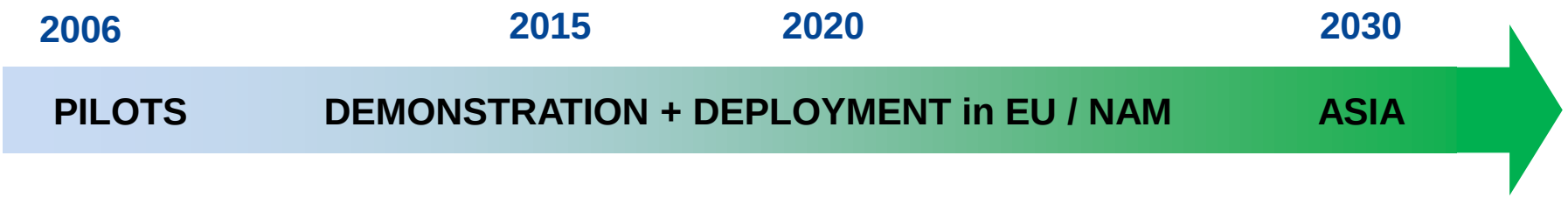
Projects

AEP AMERICAN ELECTRIC POWER
Drax Group plc
BOC
we
e·on
DOW
中国大唐集团公司 China Datang Corporation
TOTAL
VATTENFALL
ADEME
ECLAIR CLC
EPRI ELECTRIC POWER RESEARCH INSTITUTE
NETL
nationalgrid
EDF ENERGY
Schlumberger
ROMGAZ
ISPE
TRANSGAZ MAGISTRALA ENERGIEI
TECHNOLOG CENTRE MONGSTAD

What we've achieved

- technology works
- capture – transport – storage integrated
- 90 % capture at 99% purity
- energy penalty falling





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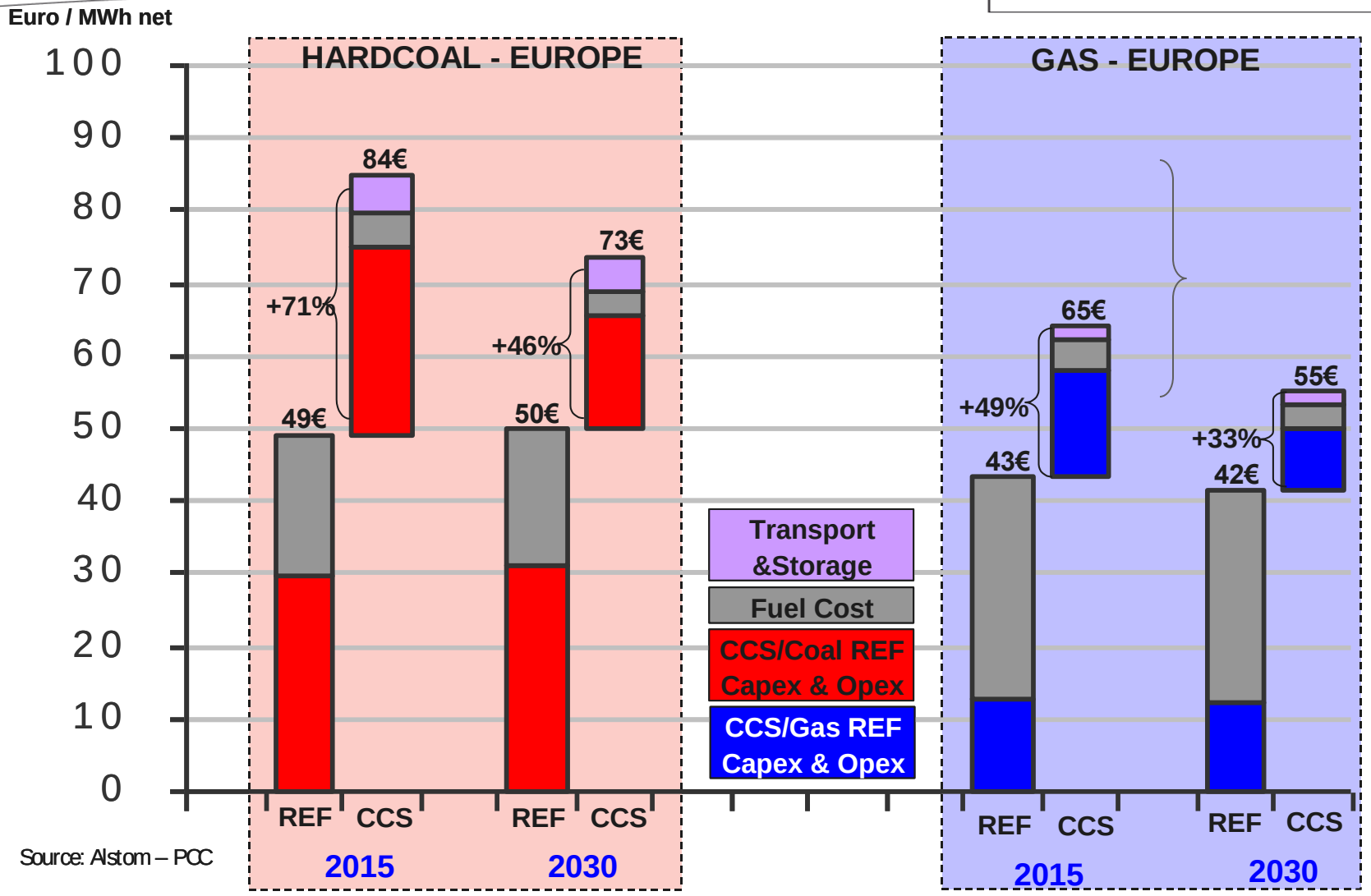
CCS is affordable



Source: Alstom – PCC

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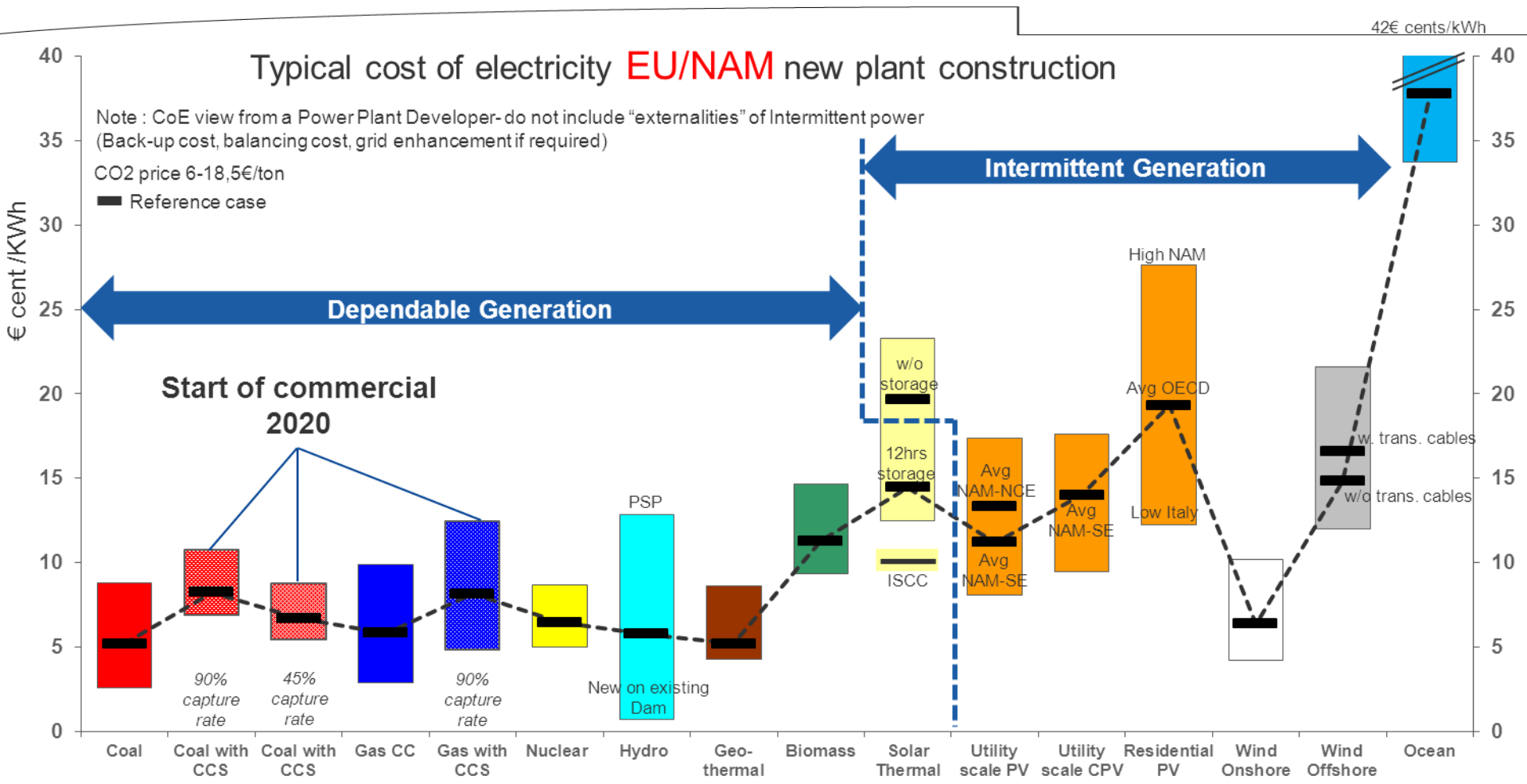
Investment decision for New PP over next 5 years
Cost of Electricity by type - Expected range



Coal remains a low cost option in most OECD countries

Coal with CCS will be competitive with all other decarbonized power solutions

Building a diversified portfolio remains safest customer option over the long run

Full-scale demonstration: White Rose, UK

- 426MW
- Oxy-Combustion
- FEED study underway
- NER300 grant €300m
- UK feed-in tariff
- Commissioning 2018-19

ALSTOM drax BOC A Member of The Linde Group nationalgrid

CCS in Poland: Belchatow

- €180m EU grant
- FEED completed
- Permits for plant
- Storage site chosen
- Pipeline routed
- Strong Lodz support
- Strong EU support

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Why do CCS in Poland ?

- Technology leadership
- Local economic benefits
- License to operate coal
- Energy security
- Affordable and viable

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CCS in Poland: finance options

- Free EU ETS allowances
- NER400
- EU Structural and Cohesion Funds
- Norway EU grants 2015-19
- EIB / EBRD
- EU €300bn Infrastructure Investment Package

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CCS in EU 2030 energy policy

2.6 the existing NER300 facility will be renewed, including for carbon capture and storage and renewables, with the scope extended to low carbon innovation in industrial sectors and the initial endowment increased to 400 million allowances (NER400). Investment projects in all Member States, including small-scale projects, will be eligible;

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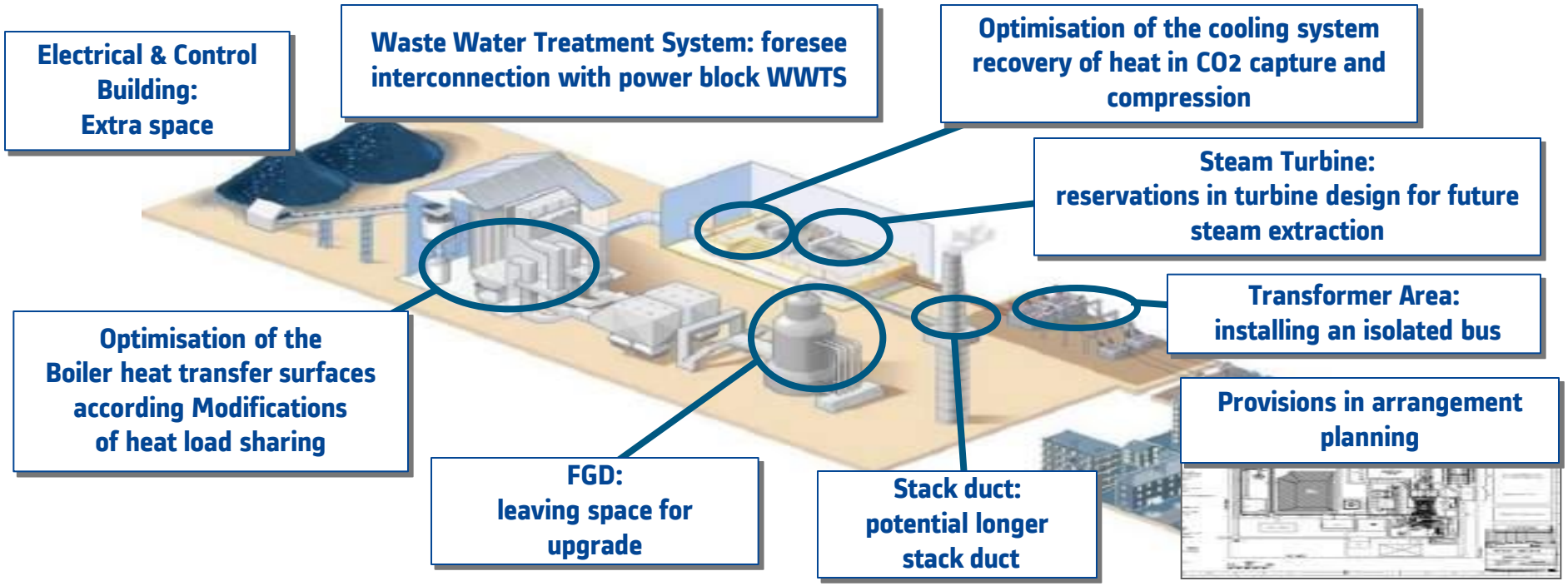
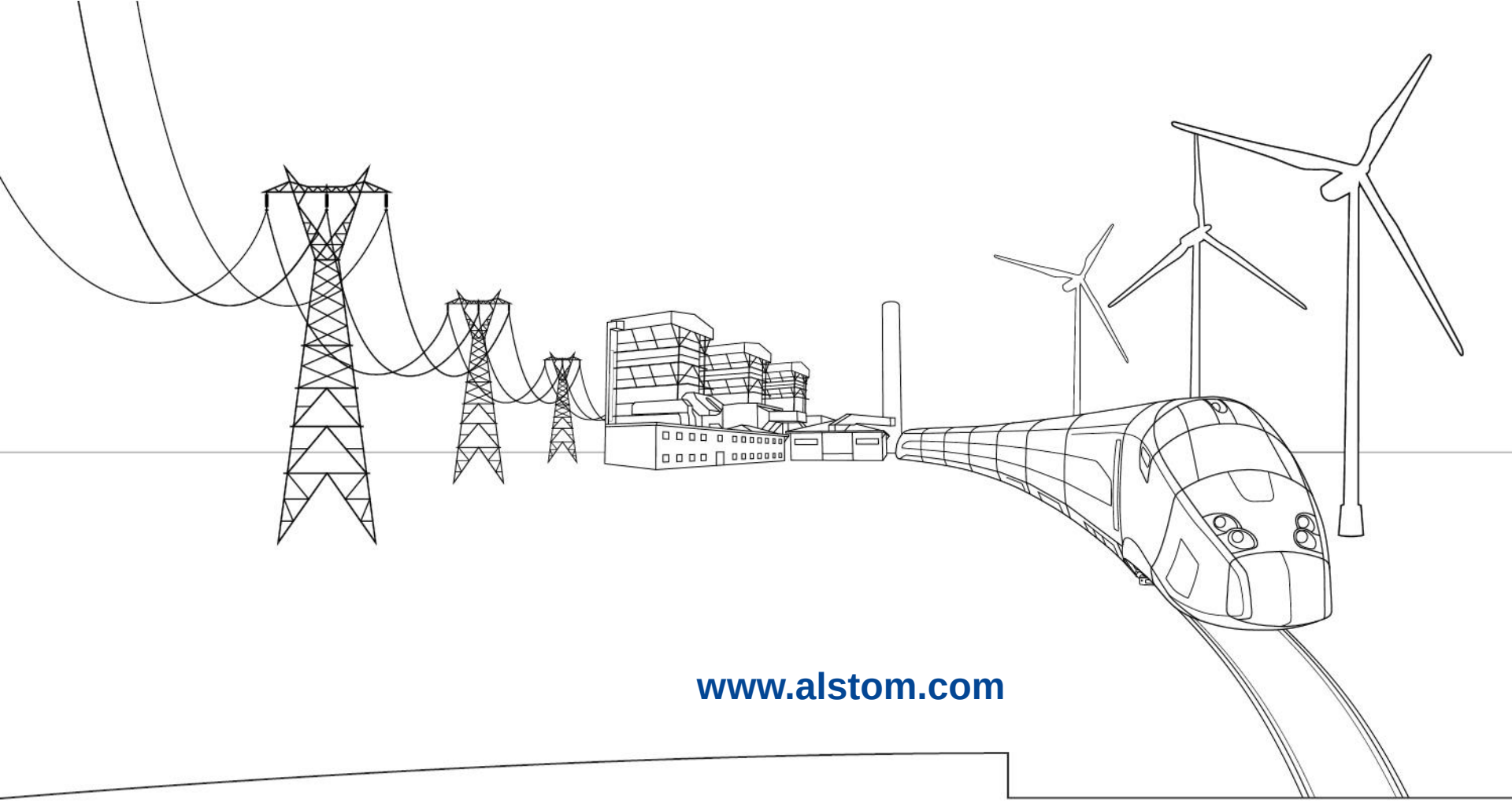
Build new plants capture-ready



- **Must be conducted in parallel with CO2 transport and storage feasibility study**
- **Cost ~+2% on total EPC –depending on land-space reservation costs**
- **Study mandatory for European projects**



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Shaping the future

Why CO_2 Capture and Storage

To combat climate change, according to IPCC, **the atmospheric GHG concentration needs to be stabilised at 450 ppm** to limit average global temperature rise to +2°C

CO_2 Capture and Storage (CCS) is a key CO_2 abatement option for Power generation and energy-intensive Industries

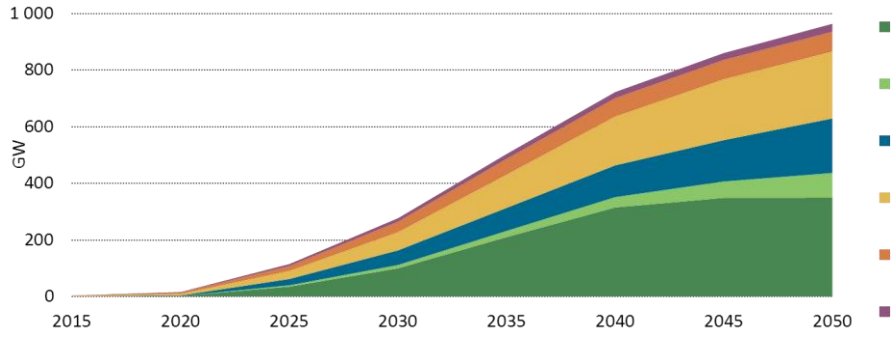
The challenge for the Power Industry : maintaining reliable and affordable low carbon electricity supply

- 2/3 of global power will be based on fossil fuels in 2035*, remaining strong through 2050
- Emissions reductions from the power generation sector crucial through:
  - ✓ Efficiency increase
  - ✓ Alternative low-carbon solutions : renewables and nuclear
  - ✓ and extensive CCS deployment by 2050 on fossil-fuelled power plants;

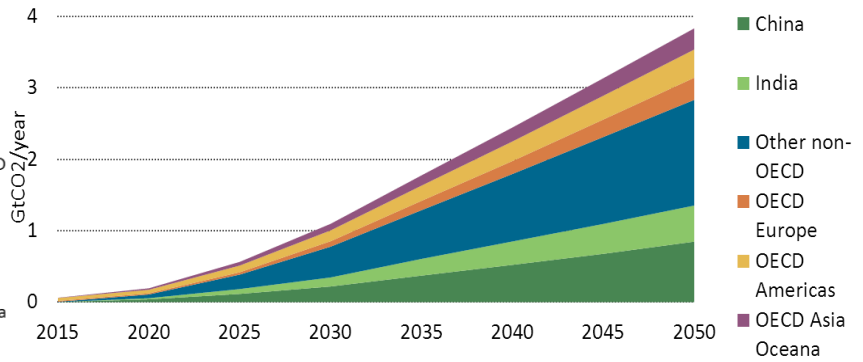
CCS applied to industry would represent 45% of the total CO_2 captured by 2050 *

- CCS can be applied to many industrial processes;
- Cement, Iron and ste-el, gas processing, bio-fuels and refining present the largest potential.

Electric power generation capacity equiped with CCS
450 ppm Scenario **



Global CCS deployment in industrial applications
450 ppm Scenario **



** From © OECD/IEA, WEO 2012, Current Policies Scenario*

***From © IEA/OECD, Energy technology Perspectives 2012 , Paris*

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Market overview
CO_2 Capture technologies

Post-combustion
(New + retrofit)

Post-combustion

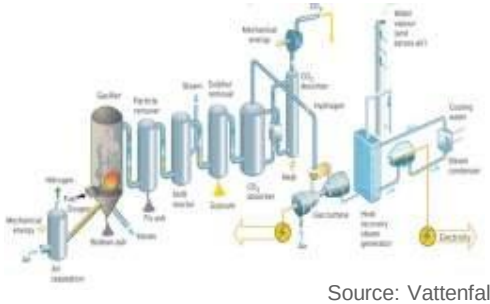
- Chemical absorption of CO_2 (advanced amines and chilled ammonia).
- Flue gas is contacted with a chemical solvent which reacts with the CO_2 or is captured by physical process. Raising the temperatures reverses the above reaction – releasing CO2 and allowing the solvent to be recycled

Oxy-combustion
(New + retrofit)

Oxy-combustion

- Fuel is burned in a mixture of oxygen and re-circulated flue gas. Due to the absence of Nitrogen, the resulting flue gas is rich in CO_2.
- After water condensing and further purification, CO_2 is compressed and sent for storage or re-use.

Pre-combustion
(New only)



Source: Vattenfall

Pre-combustion

- Pre-combustion (Integrated Gasification Combined Cycle - IGCC) is based on gasification which converts a fossil fuel into synthesis gas composed of CO and hydrogen. Following shift conversion ($CO+H_2O$ -> CO_2+H_2), the resulting H_2 product is burned in a gas turbine.

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Learning from others

- Knowledge-sharing from UK projects
- Strong local support Uk wr can contribute to knowledge sharing with others
- Permits
- Ccs directive
- Ppt efficiency loss 2.7 from relevant part of the block
- Pubmic acceptance engagement of govt not just accts
- Lodz support
- Technolgy warsaw polytechnic and AGH Krakow

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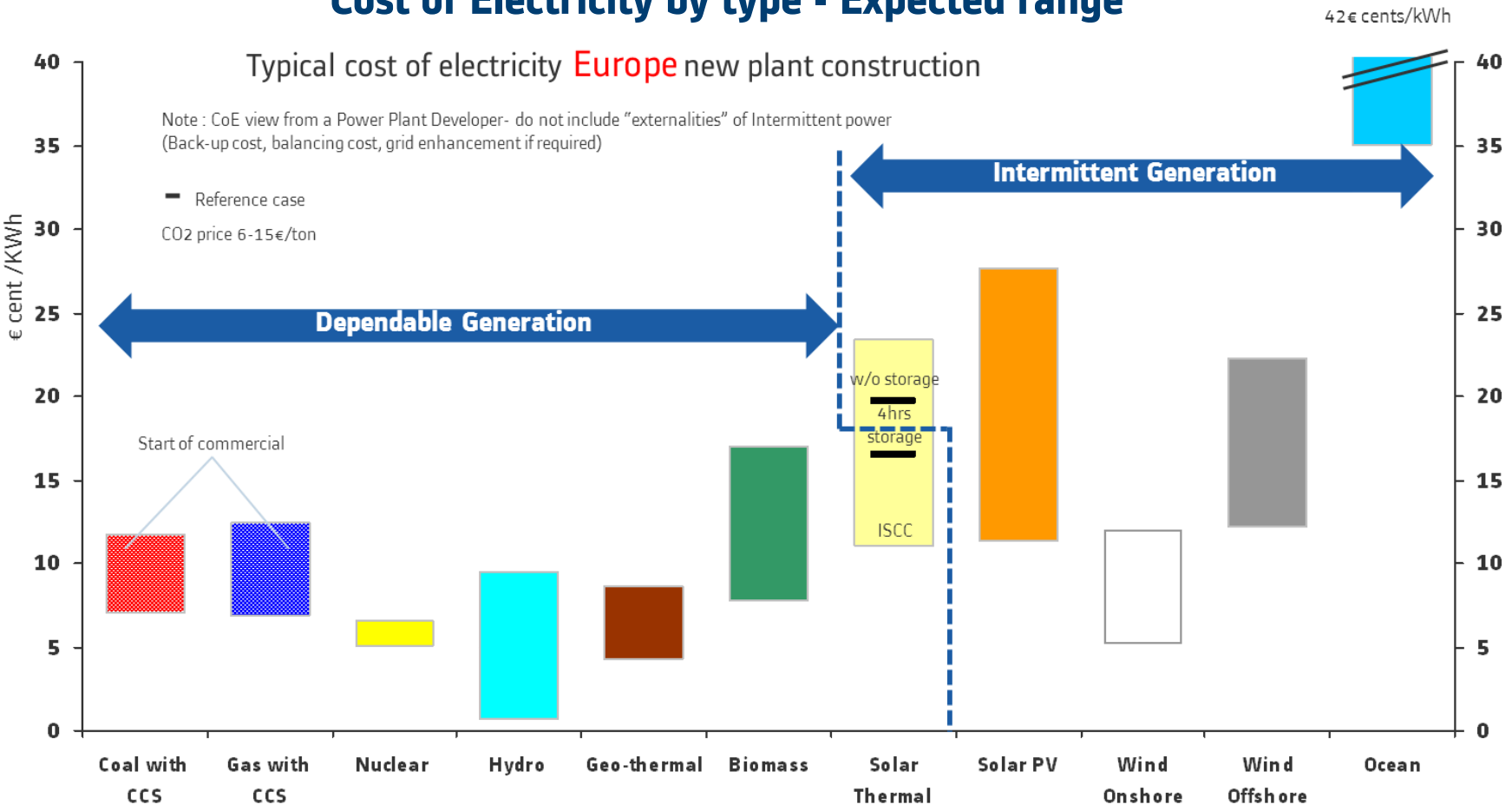
Investment decision for low carbon New PP over next 5 years
Cost of Electricity by type - Expected range



Source : Alstom analysis 2013