INTERNATIONAL ENERGY AGENCY

CO_2 Capture and Storage - Status Update

Poland CCS Roundtable

18 June, Warsaw

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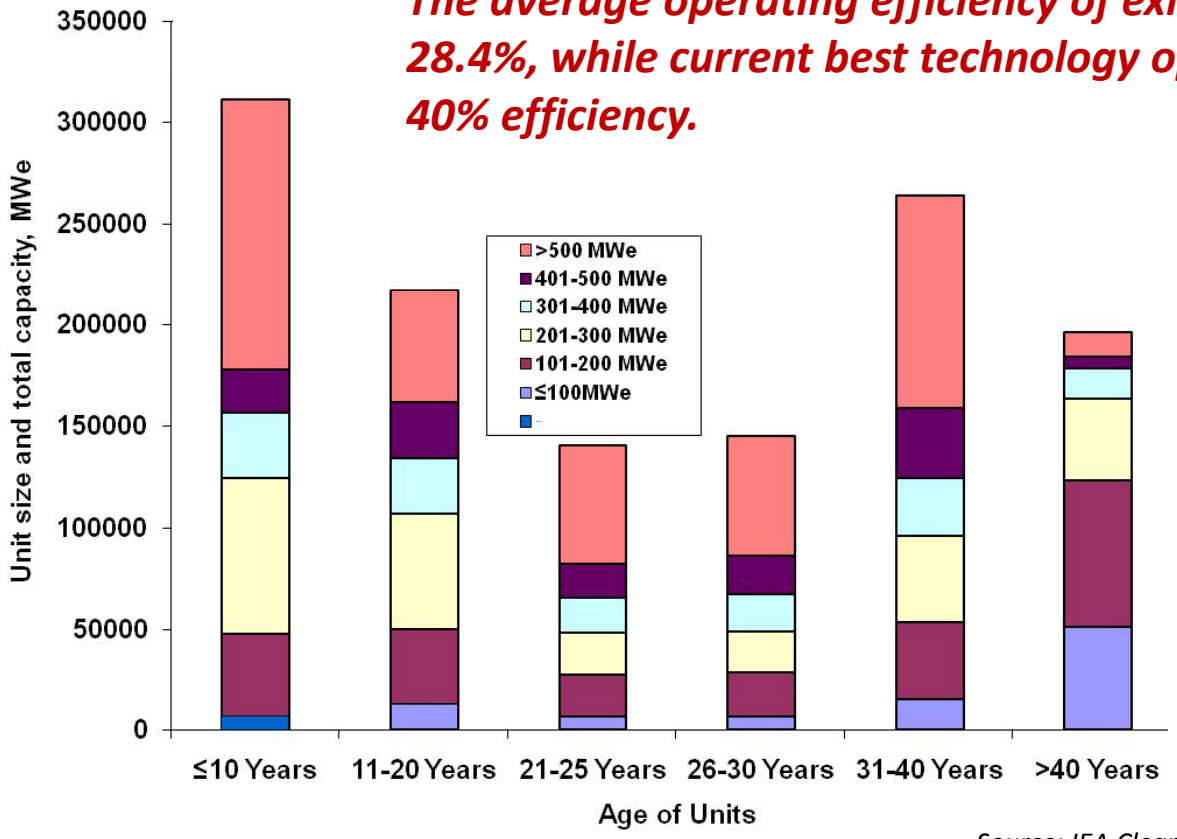
International Energy Agency

Age, size and operating efficiency of coal fleet worldwide

The average operating efficiency of existing coal fleet is 28.4%, while current best technology operates a little over 40% efficiency.



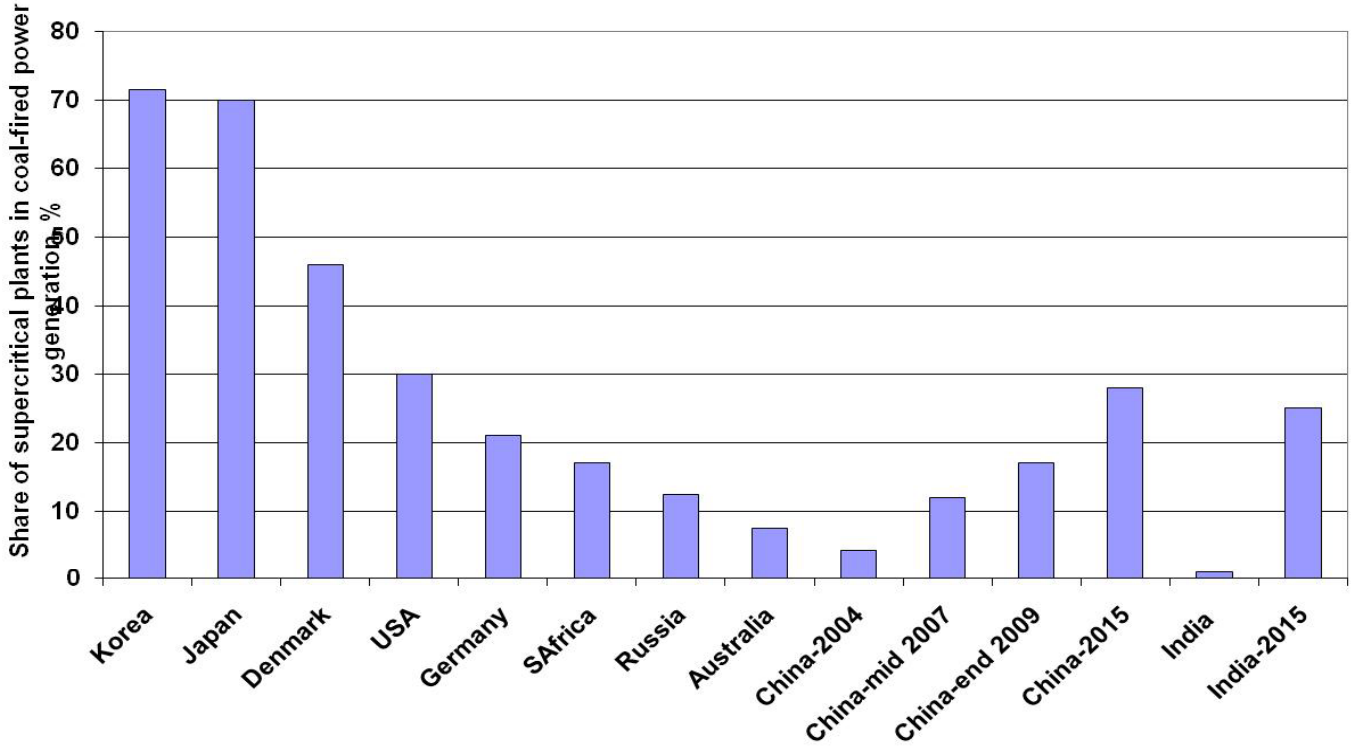
Source: IEA Clean Coal Centre

As of 2004,

- ***More than half of operating fleets are more than 25 years age and their unit size is less than 300 MWe.***
- ***More than 80% of the operating fleets are sub-critical.***

Average efficiency appears to be improving ……..

- *Retirement of smaller inefficient units, eg in China*
- *Units - recently built, under construction, and planned, eg in China, India*
  - *larger (600-1000 MW) units*
  - *'supercritical' or 'ultra-supercritical' units – inherently more efficient*
  - *more efficient boilers, even under lower loads*



Source: IEA Clean Coal Centre, China Electricity Council and Ministry of Power, India

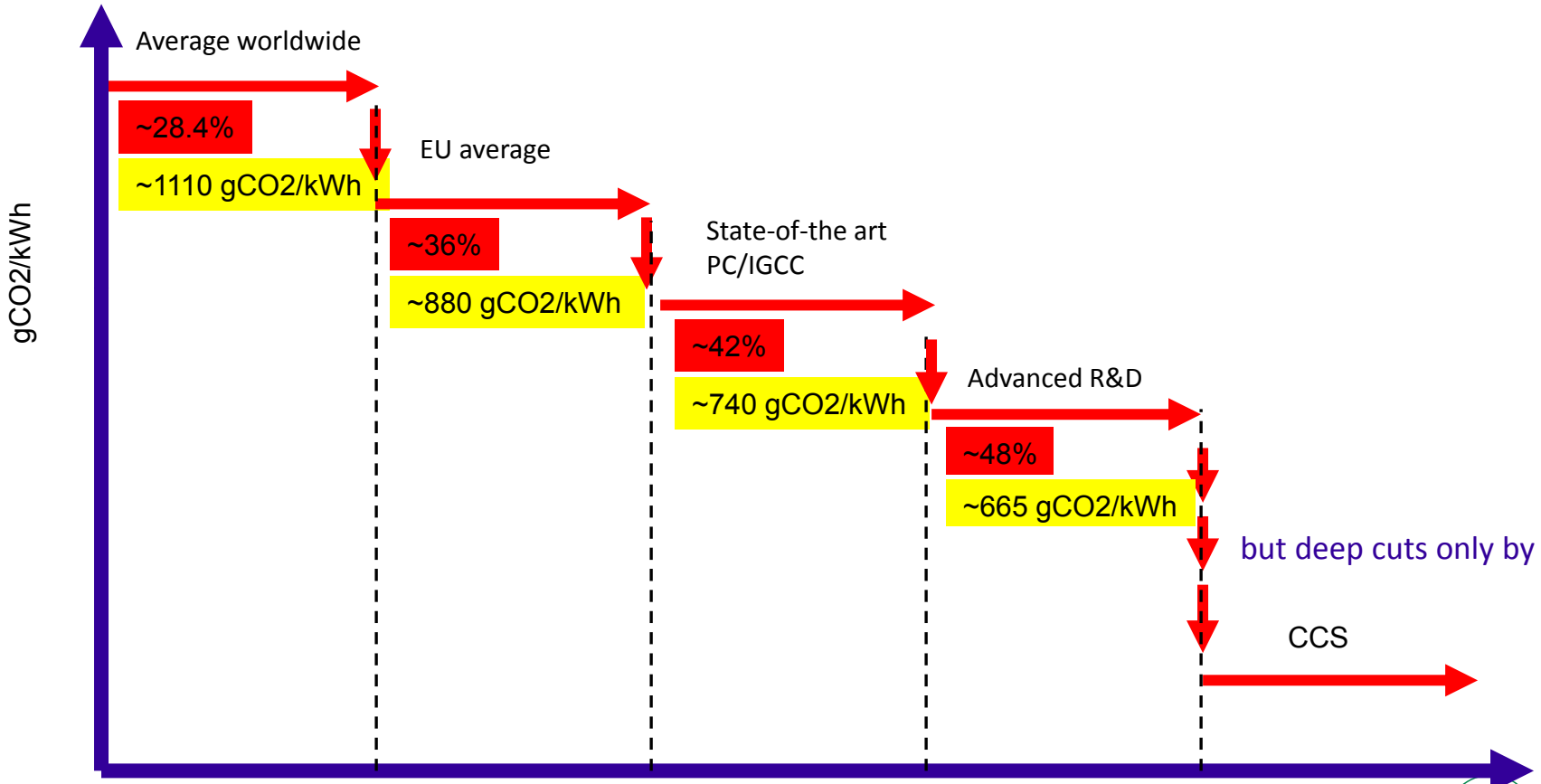
Potential improvement …… in the short term

- Coal-fired power and CHP plants worldwide account for ~25% of total CO_2 emission
  - *~7.5 billion ton/annum of CO_2 emission* in 2005

- Replacement potential - ~300 GW
- Upgrade potential - ~ 200 GW

- Globally 1.35 - 1.7 billion tonnes/annum of CO_2 reduction possible by moving to <u>current</u> state-of-the-art pc-plants – *through …..*
  - *… in excess of 0.5 billion ton/annum of reduction in coal consumption*
  - *… higher reduction with possible improvement in higher steam conditions plant – ongoing R&D requires to be accelerated*

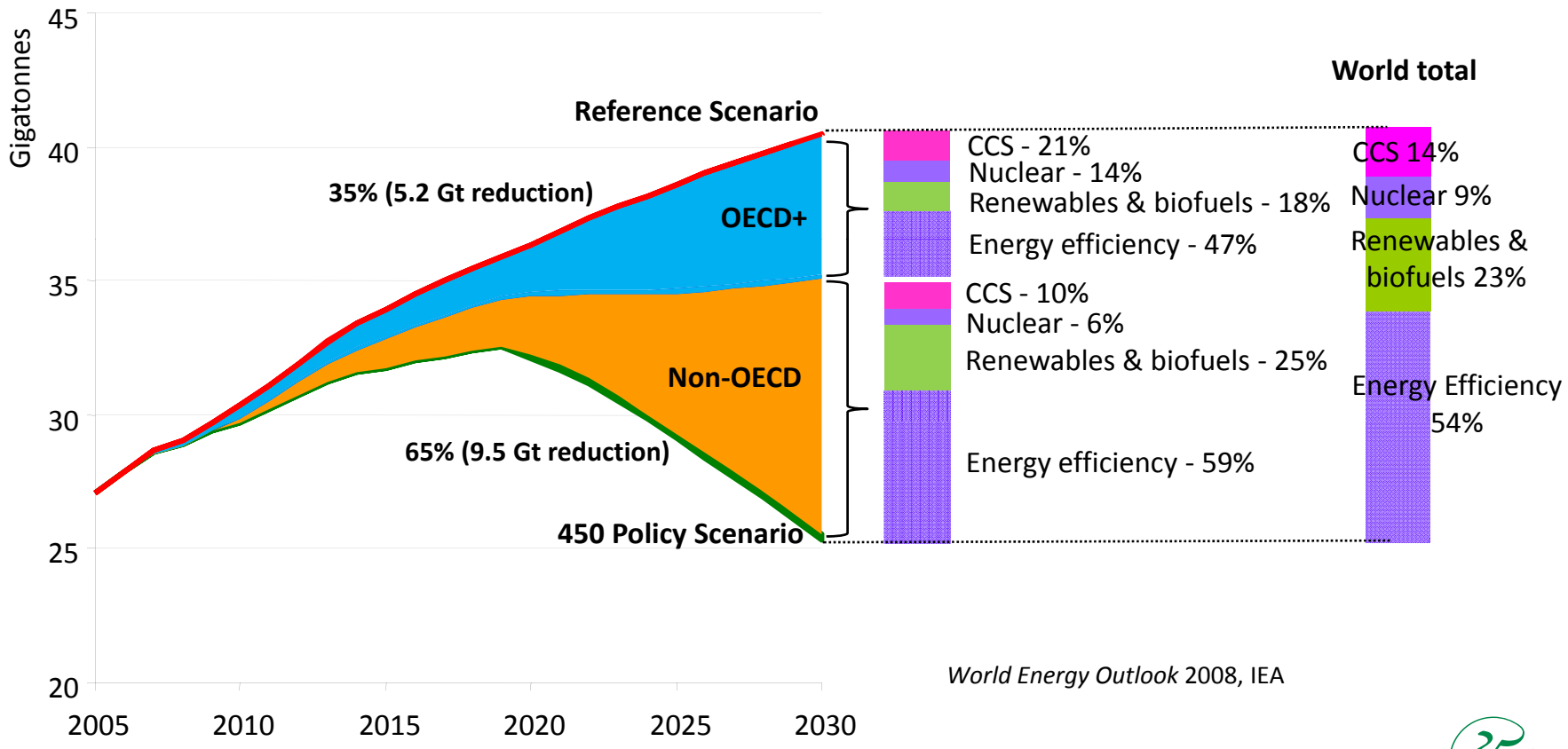
CO2 emission reduction by key technologies



adapted from VGB 2007; efficiency – HHV,net

Energy Efficiency makes big change but deep cuts of CO2 emission can be done only by Carbon Capture and Storage (CCS)

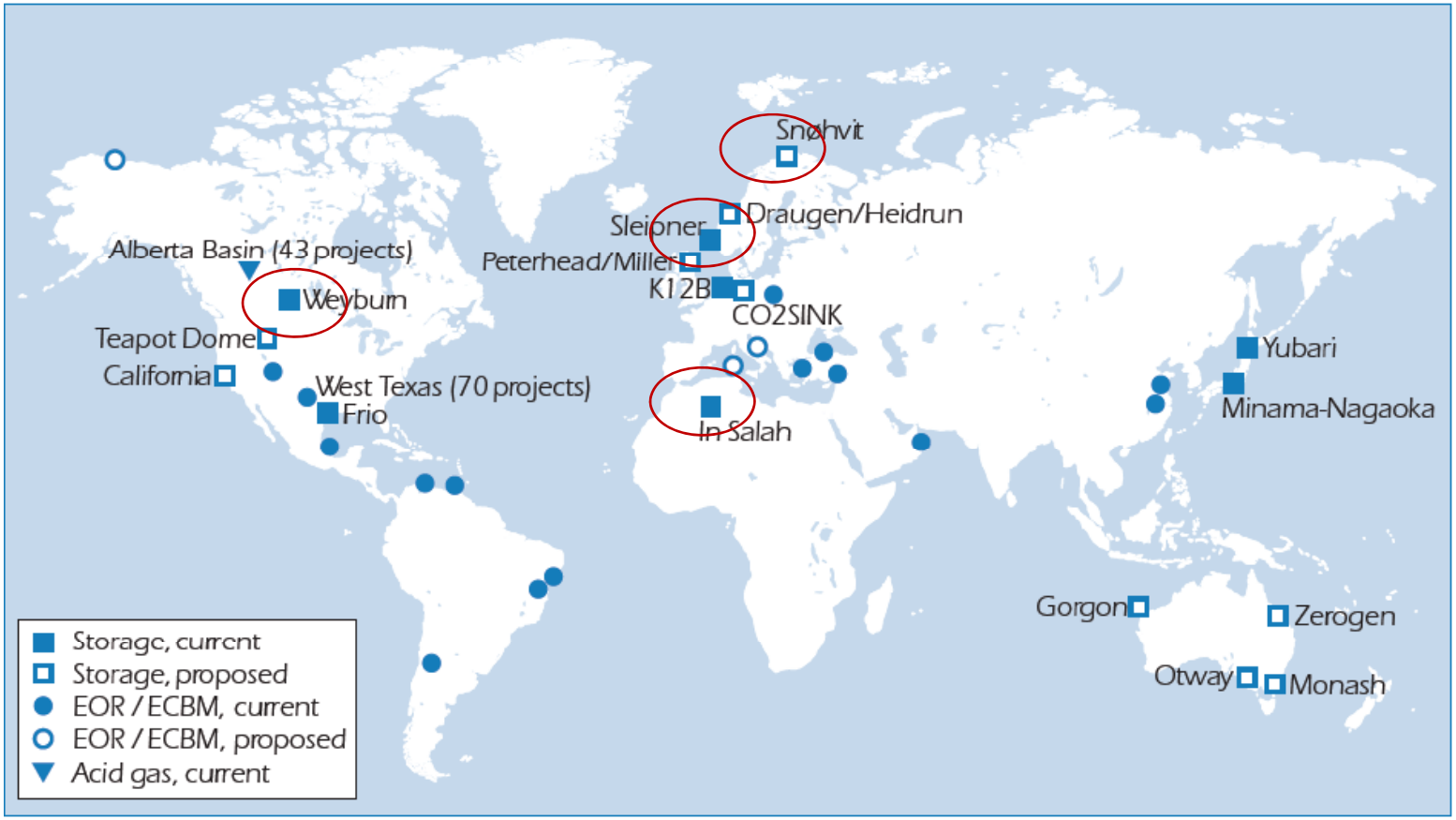
Reductions in energy-related CO2 in the 450 Policy Scenario



World Energy Outlook 2008, IEA

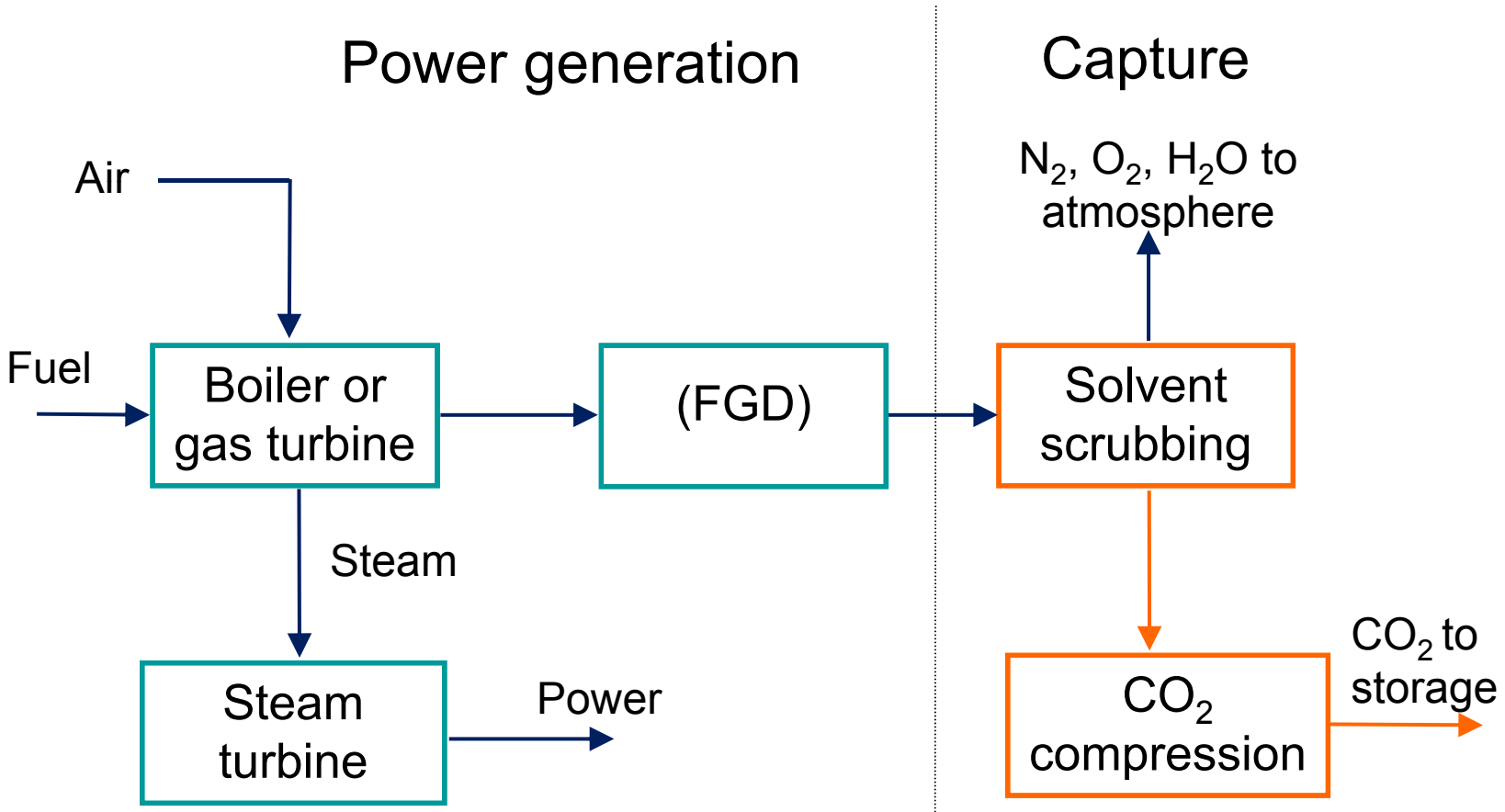
- ***OECD and non-OECD countries must both work towards reducing CO2 emissions***
- ***Energy efficiency is the largest contributor. Renewables, nuclear and CCS also play key roles.***

CCS - only 4 full-scale projects exist



G8 goal: 20 full-scale demonstrations announced by 2010

Post-combustion capture



China's 1st post-combustion CO_2 capture pilot plant

Design parameters:

- **Flue gas flow to unit 2000-3000 Nm^3/h**
- **Steam consumption**

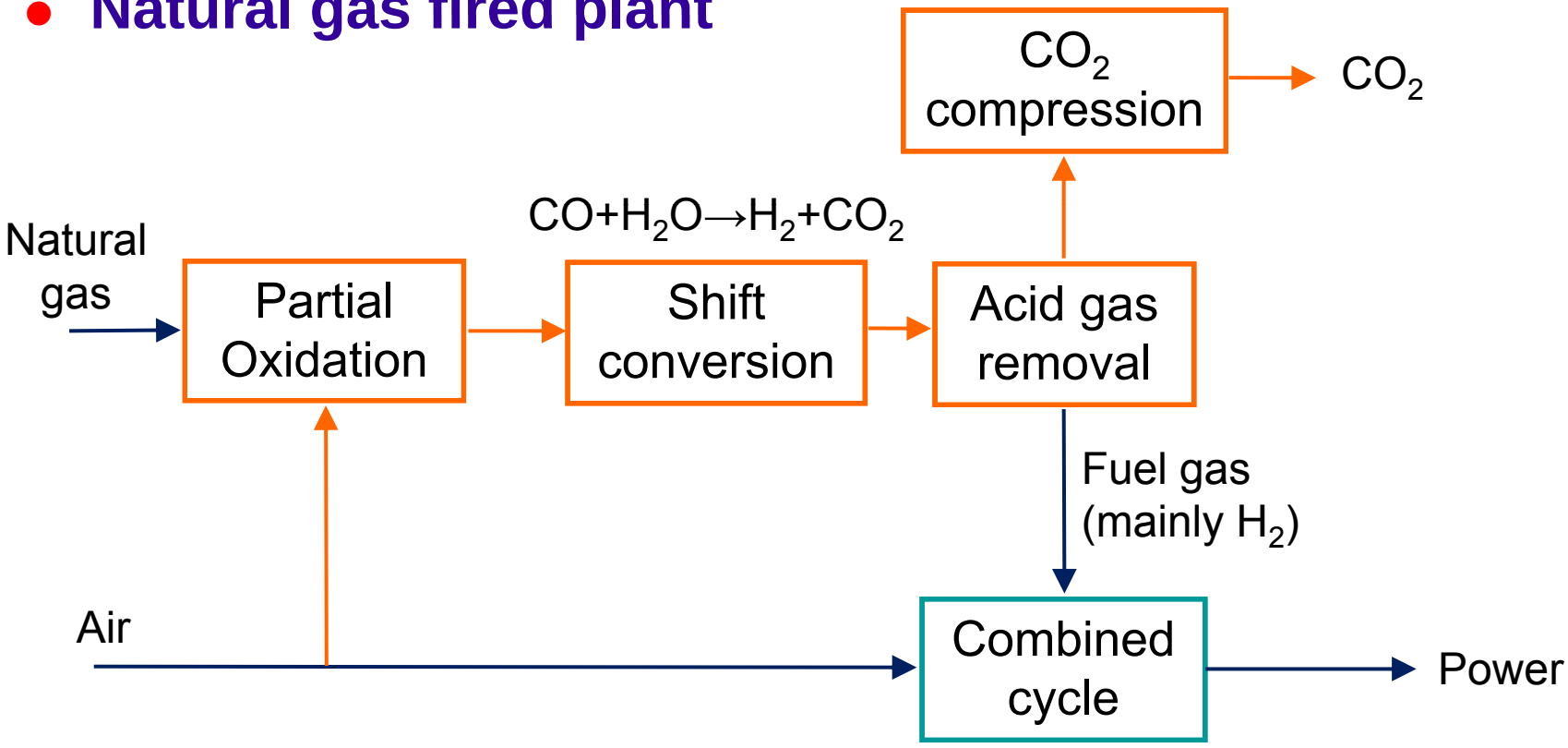
  3 GJ/tonne CO_2
- **CO2 captured**

  3000 tonnes/year
- **Solvent consumption**

  < 1.35 kg/tonne CO_2

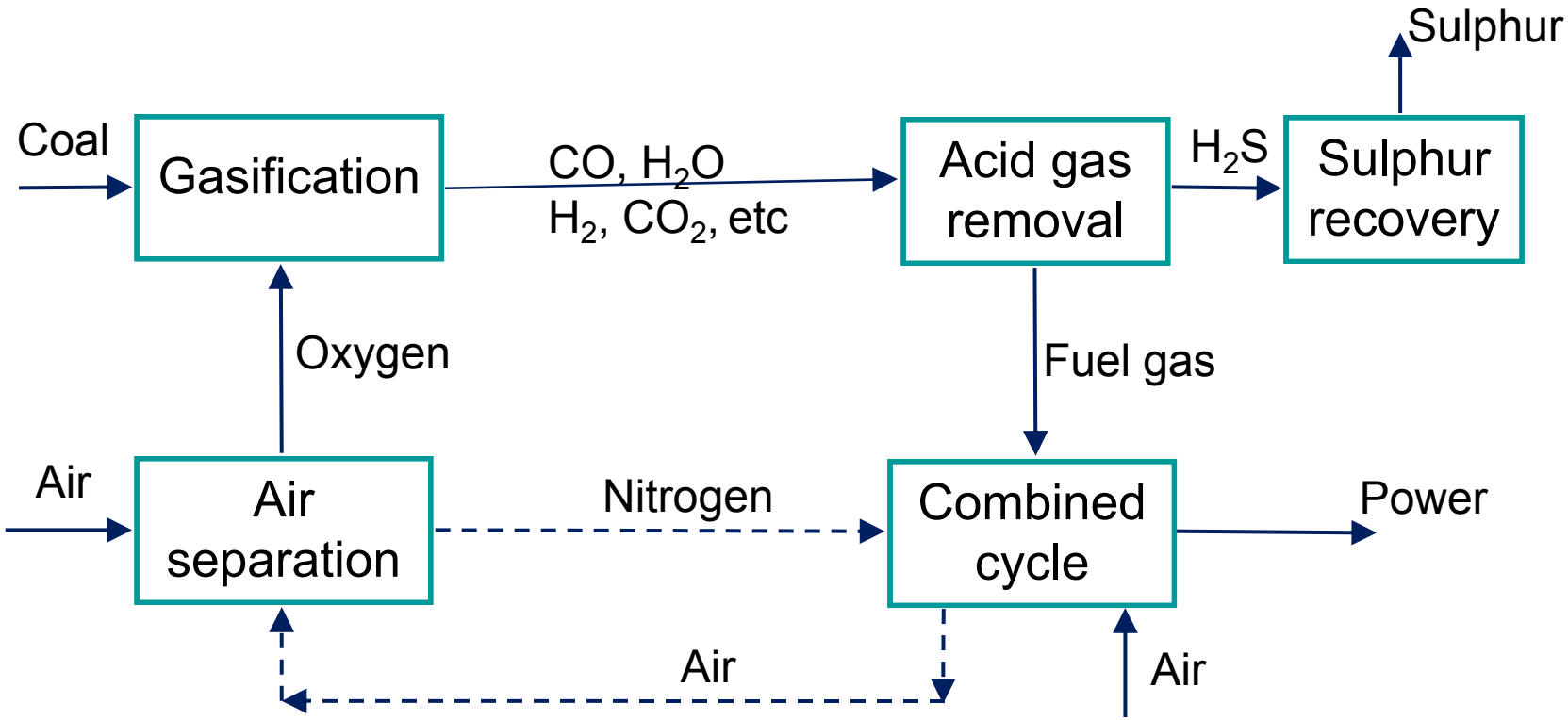
Pre-combustion capture

- **Natural gas fired plant**



Pre-combustion capture

- **IGCC without CO_2 capture**

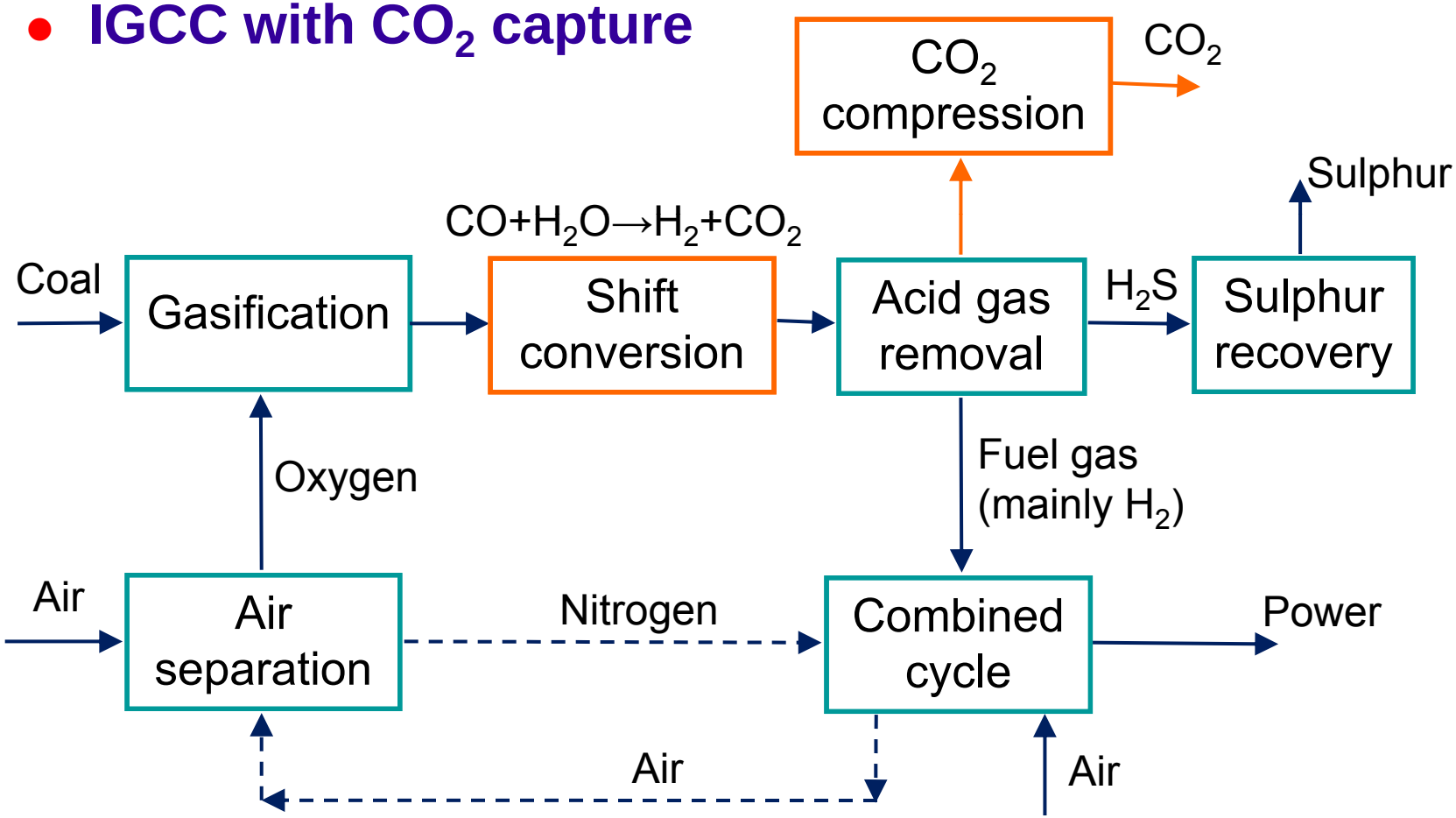


IGCC without CO_2 capture

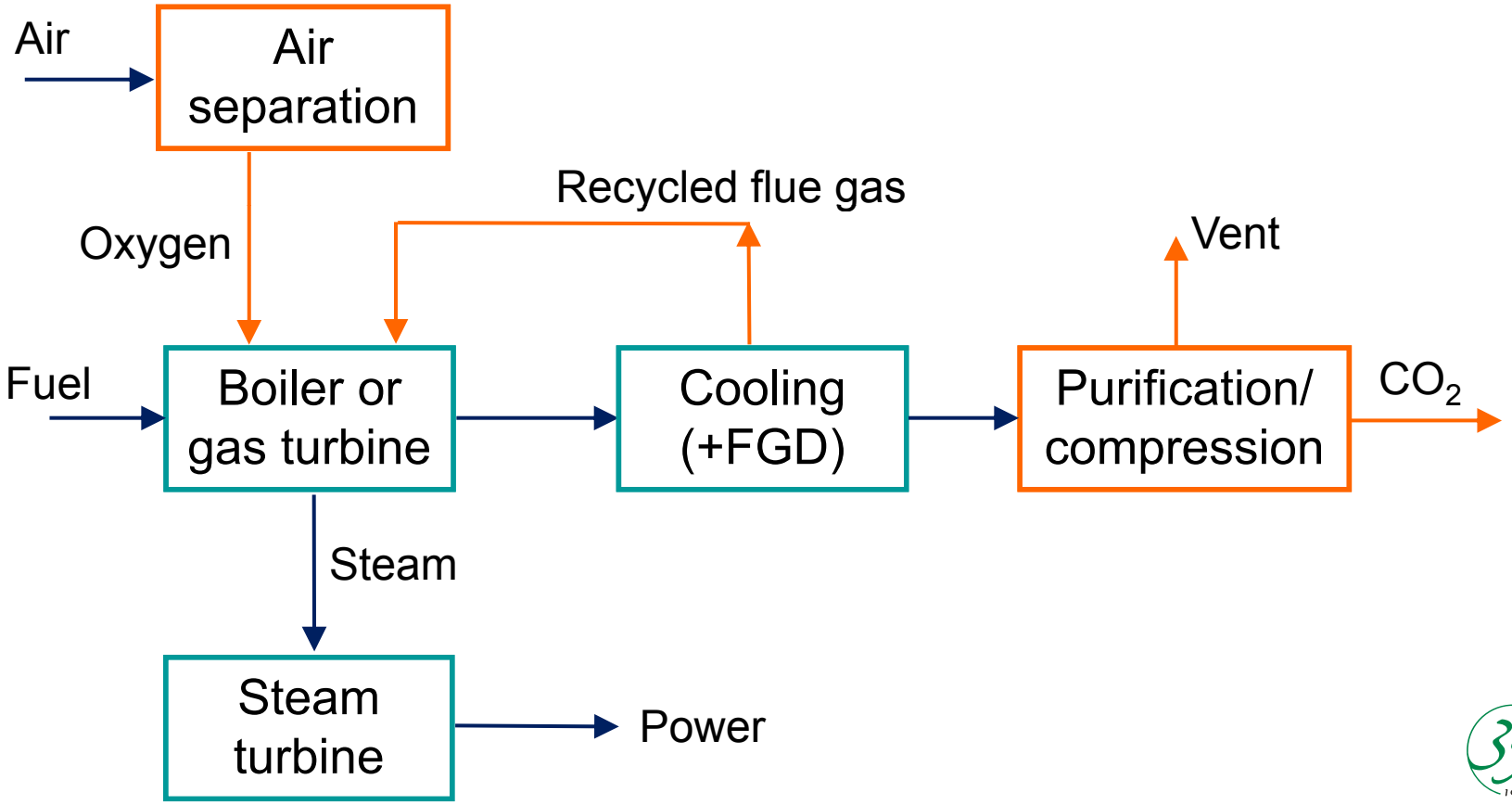
Shell gasifier IGCC plant, Buggenum, Netherlands

Pre-combustion capture

- **IGCC with CO_2 capture**

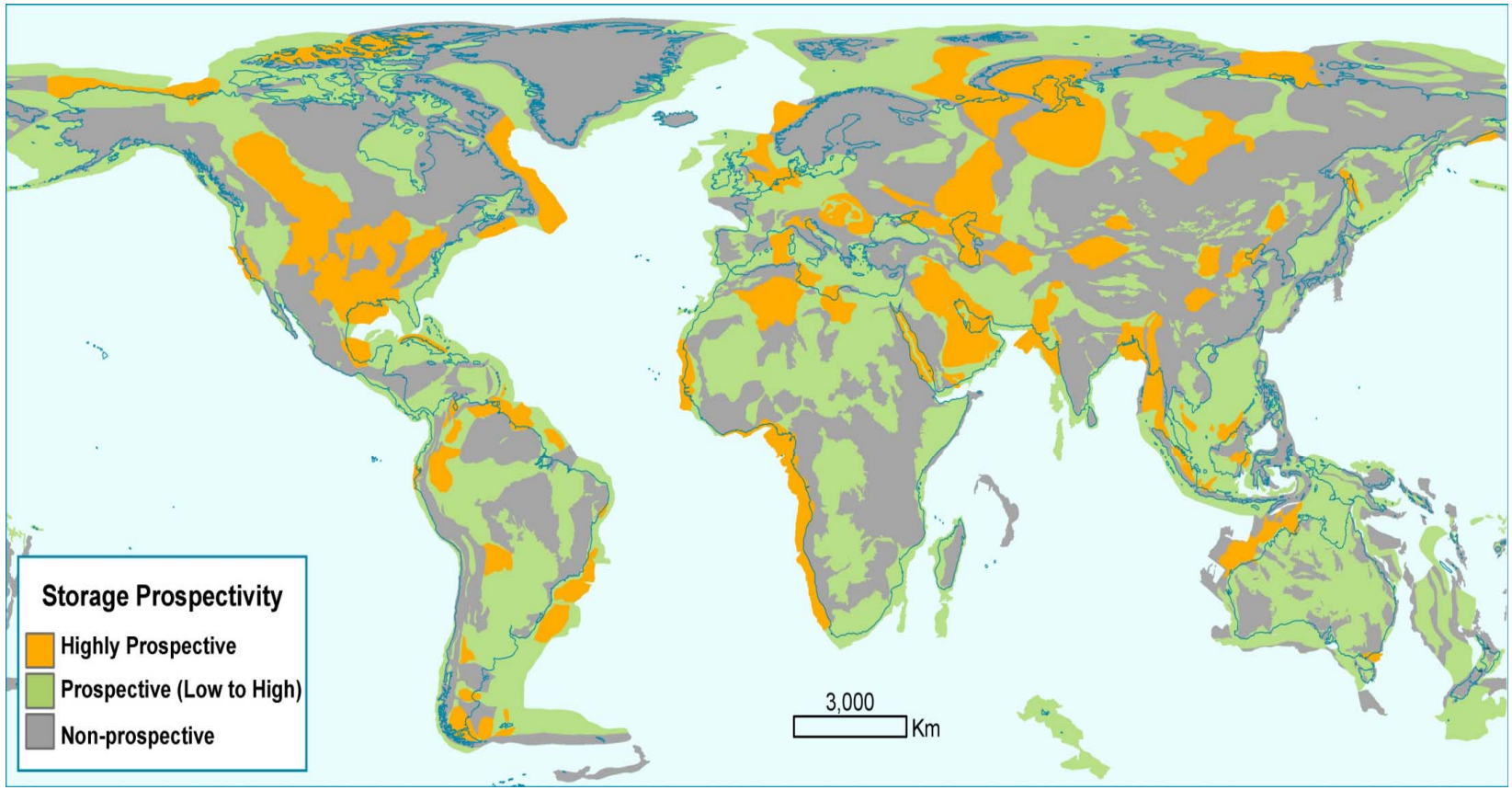


Oxy-combustion



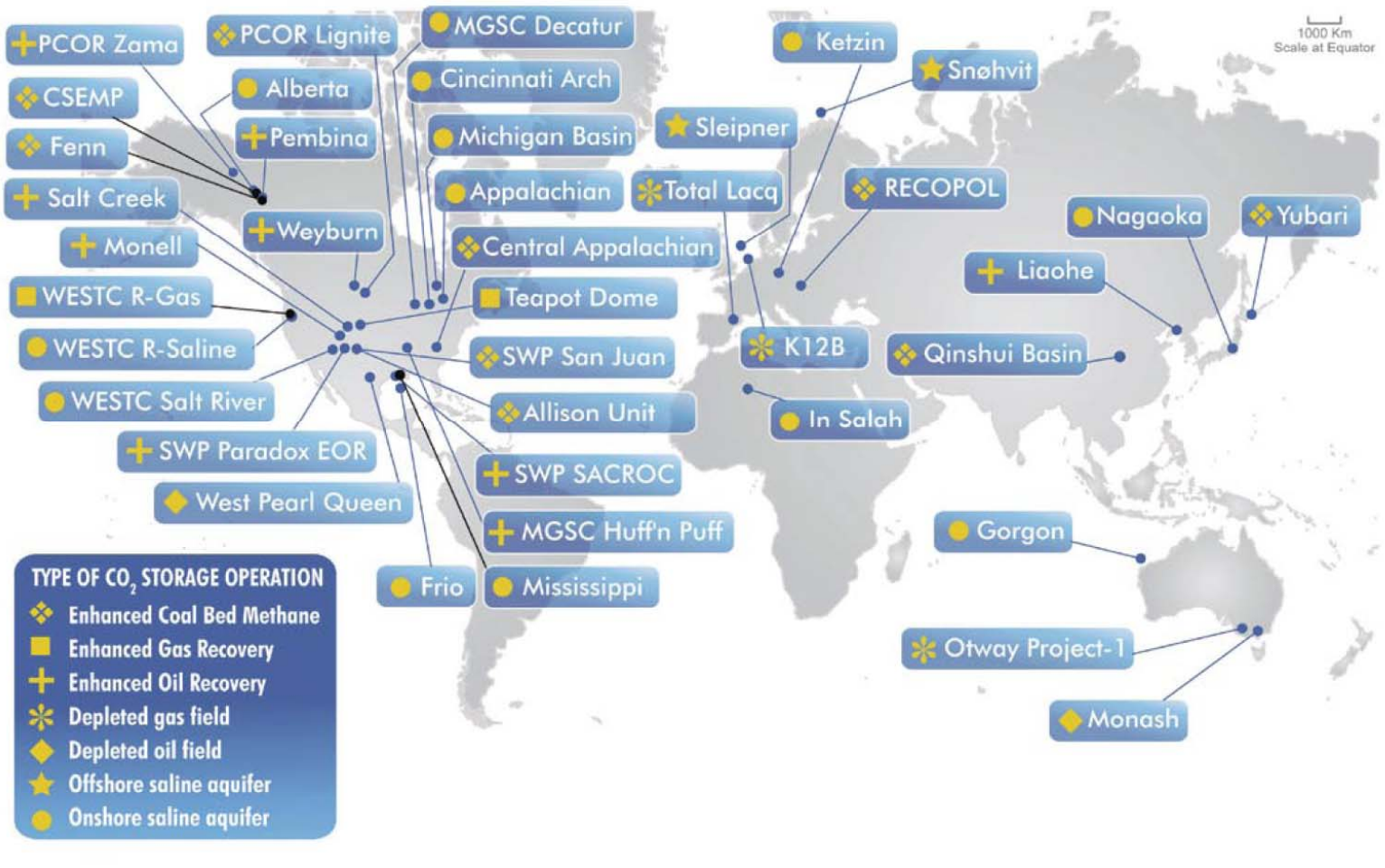
Vattenfall's 30 MWth oxyfuel carbon capture unit

CO_2 storage prospectivity



Source: Bradshaw, J. and Dance, T. (2004): *"Mapping geological storage prospectivity of CO2 for the world's sedimentary basins and regional source to sink matching,"* in (E.S. Rubin, D.W. Keith and C.F. Gilboy eds.), GHGT-7, Proc. Seventh International Conference on Greenhouse Gas Control Technologies, Vancouver, B.C., Canada, September 5-9, 2004.

CO_2 storage demonstration projects



Source: IEA GHG, *Carbon Capture and Storage: Meeting the Challenge of Climate Change* (2008).

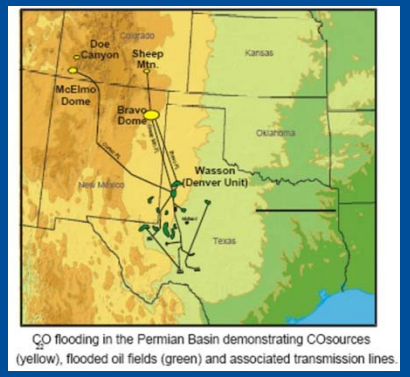
Experience of CO_2 transport

ICO2N

Pipeline network to capture and supply 1.2Mt/y CO2 by 2010

Weyburn 300km transboundary pipeline

Snohvit 160km sub-sea pipeline



CO_2 flooding in the Permian Basin demonstrating COsources (yellow), flooded oil fields (green) and associated transmission lines.

Permian Basin, 3000km pipeline network operating since mid 80's

Extensive experience of long-distance transport of CO_2 by pipeline

Experience of CO_2 capture and injection

Snohvit capturing and injecting 0.7Mt/y CO_2 since 2008

Sleipner capturing and injecting 1Mt/y CO_2 since 1996

Rangeley injecting 3 Mt/y CO_2 since 1980s

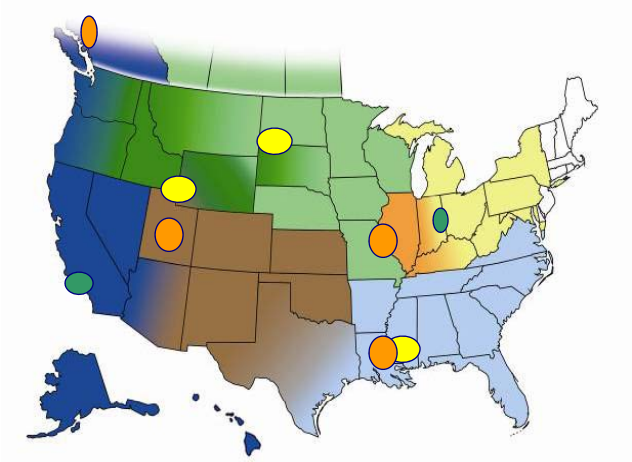
Weyburn capturing and injecting 1Mt/y CO_2 since 2000

In-Salah capturing and injecting 1Mt/y CO_2 since 2004

Currently 7Mt/y … though none involves integrated CO_2 capture, transport and storage from a coal-fired power plant.

Commercial-scale developments

- US Regional Carbon Sequestration Programme
  - 9 planned 1Mt/year projects to start before 2011
    - Many are integrated projects



- Planned Aquifer projects in Canada could add 6-8Mt/y CO2 captured and stored by 2012

CCS initiatives I

- **Australia**
  - The Clean Energy Initiative – provides support for large scale demonstrations of solar power and carbon capture and storage (CCS)
    - AUD $ 2 billion for 2-4 industrial scale CCS demonstration projects
  - The Carbon Pollution Reduction Scheme (CPRS) was released on 15 December 2008.
    - The CPRS provides the policy framework for an Emissions Trading Scheme (ETS)
    - Covering all Kyoto greenhouse gases and nearly all sectors of the Australian economy
    - Legislation is scheduled for consideration by the Australian Parliament later this year.
  - The Australian Government has begun a process to issue some exploration permits for offshore CO2 Storage.
    - Applicants can bid to obtain an assessment permit, which has a term of six years. In that time, the permit holder will have the right to explore for CO2 storage and, if successful, the right to convert the permit into an injection licence.

CCS initiatives II

- **Netherlands**
  - **Shell project**
    - **Capture >0.2 Mt CO2/year from the Shell's Pernis refinery. CO2 to be stored in a nearby depleted gas field. >2 million tons to be stored. Start around 2011.**
  - **DSM/GTI (Cofely) project**
    - **Capture >0.2 Mt CO2/year from an ammonia production unit. Storage in chalk/sandstone layers (including coal layers). >2 mln tons will be stored. Start around 2011.**
  - **NUON IGCC project**
    - **1-2% of the produced syngas (representing about 2.5-4 MWe) from the Buggenum IGCC plant to be captured in a side stream. Startup early 2010.**
  - **SEQ oxyfuel project**
    - **50 MWe gas fired oxyfuel plant to be constructed. Captured CO2 tobe stored offshore in a depleted gasfield. Startup foreseen for 2010.**

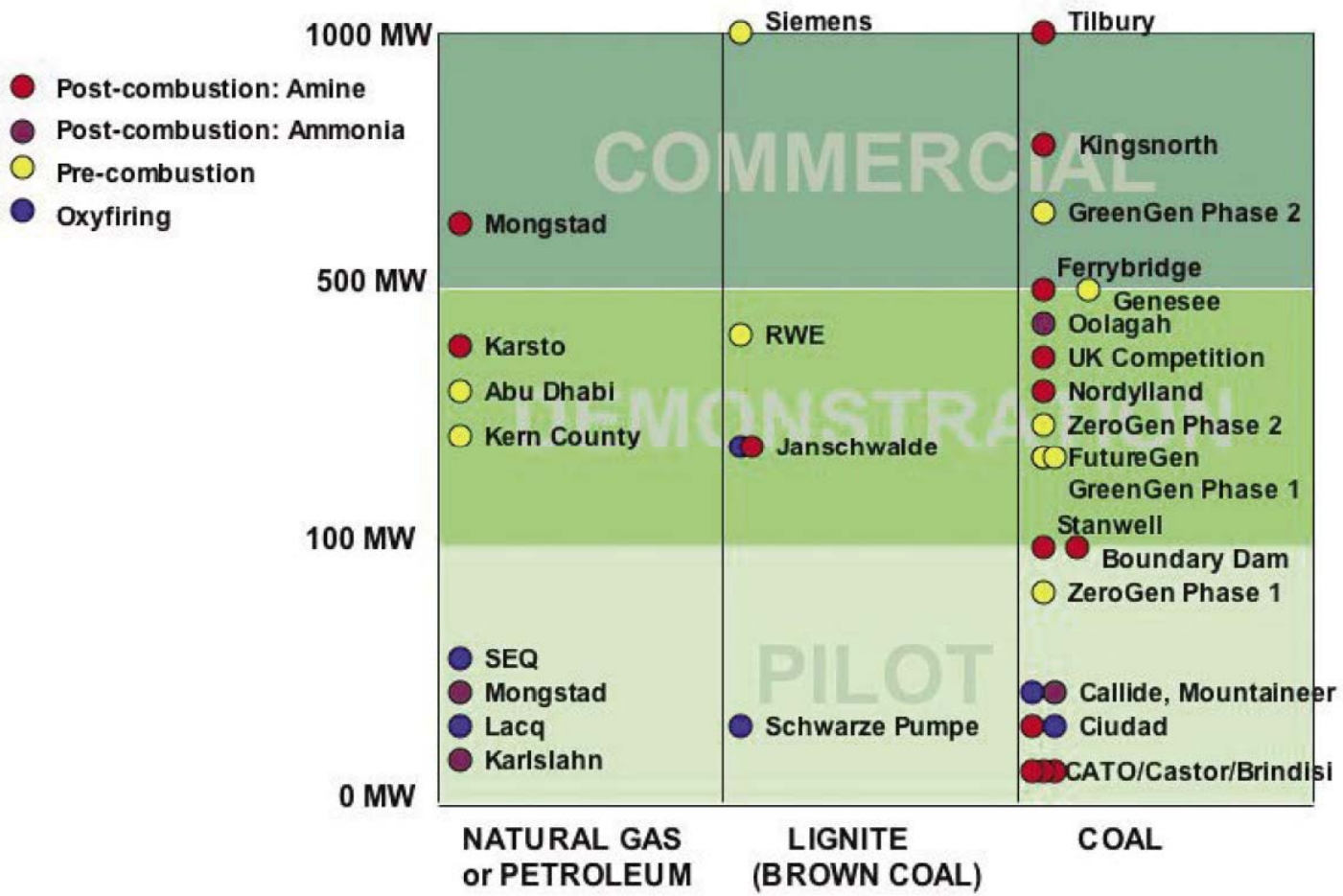
CCS initiatives III

- **Norway**
  - **Sleipner**
    - **World's 1st commercial CCS project. started in 1996**
    - **StatoilHydro separating and storing >1 million tonnes/a CO2**
    - **Injection into a saline aquifer**
  - **Snohvit**
    - **StatoilHydro separates c.700 000 tonnes/a CO2 at its LNG plant**
    - **Injection into a saline aquifer**
  - **Mongstad**
    - **Technology Centre to develop and test capture**
    - **Plans to capture CO2 from 2 gas-based sources – from a CHP unit and a refinery (up to 100 000 t/a CO2)**

CCS initiatives IV

- **UK**
  - **CCS Competition**
    - **Full-scale demonstration of integrated CCS**
    - **Post-combustion, >300MWe, coal**
    - **1 of 3 candidate projects to be selected**
  - **Further CCS demonstration**
    - **Recent announcement that 1 to 3 full-scale CCS projects to be funded**
    - **Financed substantially via a levy on electricity bills**
    - **Requires primary legislation**

Snapshot of projects (GHG IA 2008)



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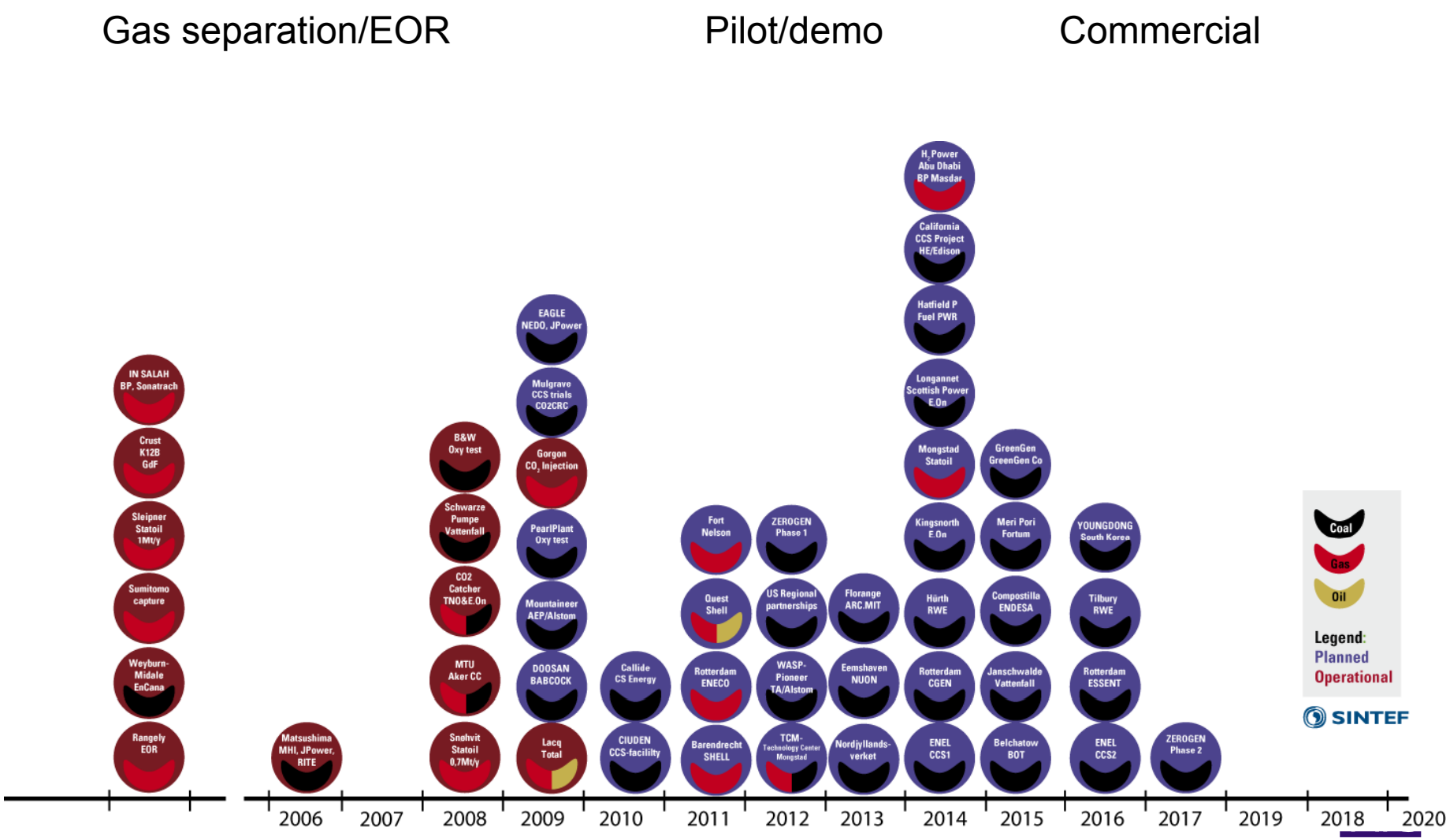
Snapshot of projects (SINTEF 2009)



Thank you!

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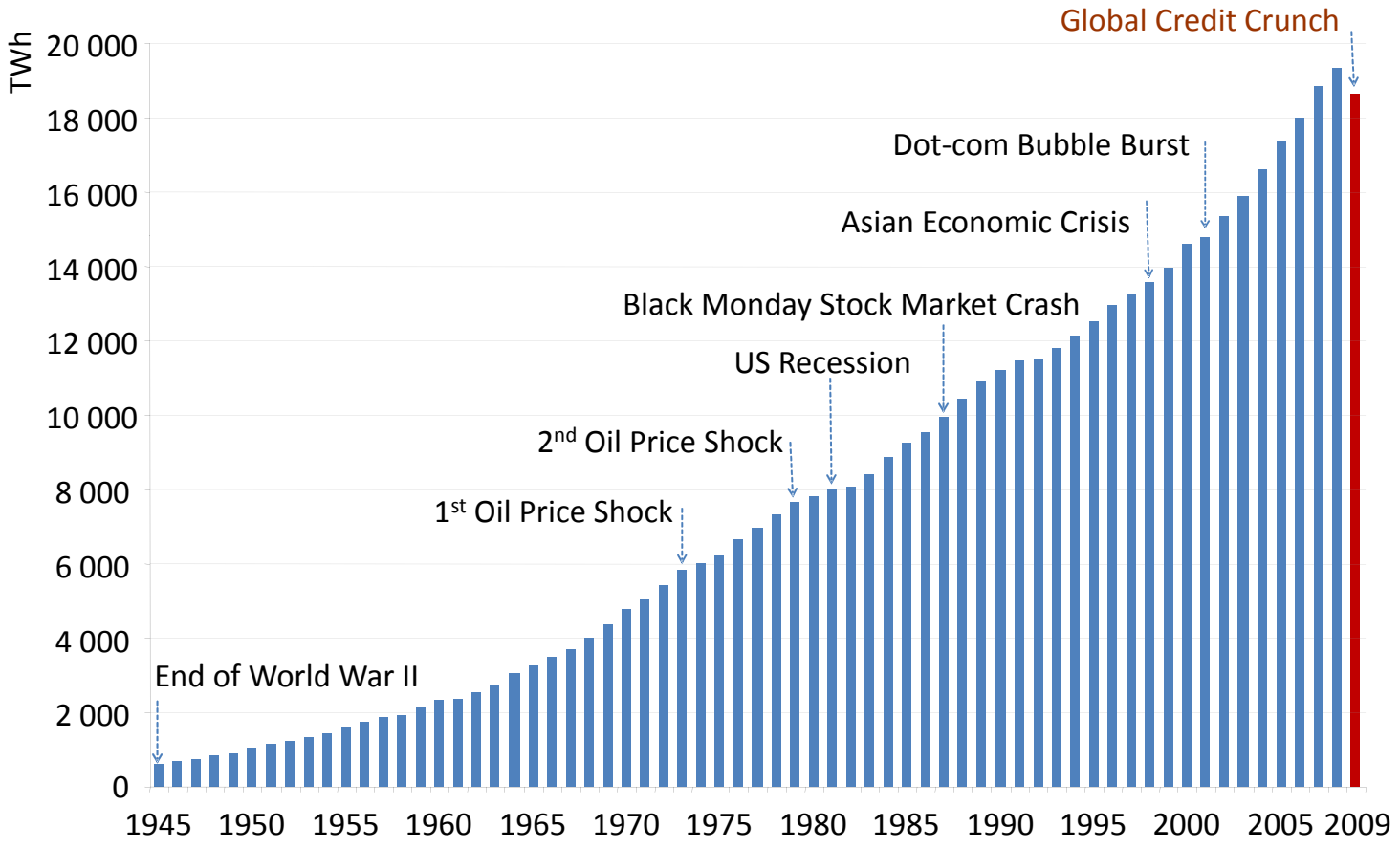
Historical global electricity consumption



The IEA estimates that global electricity consumption could drop by as much as 3.5% in 2009, the first contraction since the end of the Second World War.