Presentation 02:

CO_2 Capture and Storage:

An Essential Technology in Reducing Greenhouse Gas Emissions from Fossil Fuel Fired Power Station

Stanley Santos

IEA Greenhouse Gas R&D Programme

BANPU Sustainability Development Meeting

23rd March 2010

Presentation Outline

- ***Brief introduction to CO_2 Capture and Storage***
  - Why we need CO_2 Capture and Storage.
  - Challenges faced by CCS
- ***Concluding Remarks***

Key Message

- ***We need a portfolio of technologies to reduce GHG global emissions!***

The coal fueled Fiddlers Ferry power station emits vapour into the night sky on November 16, 2009 in Warrington. Photograph: Christopher Furlong/Getty Images

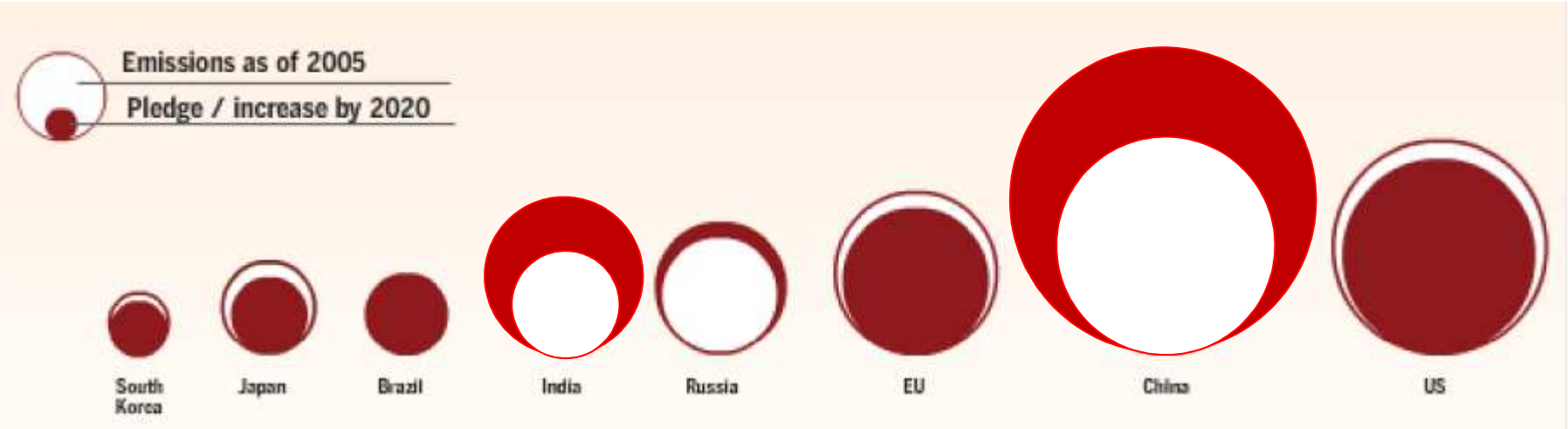
- ***Why CCS?***
  - Our grandchildren will still use electricity from coal fired power plants! <u>We need CCS to mitigate the emissions from coal.</u>

Smoke bellows from the chimneys of Belchatów power station in Poland

WHY WE NEED CO_2 CAPTURE AND STORAGE

Government Pledges for Copenhagen…

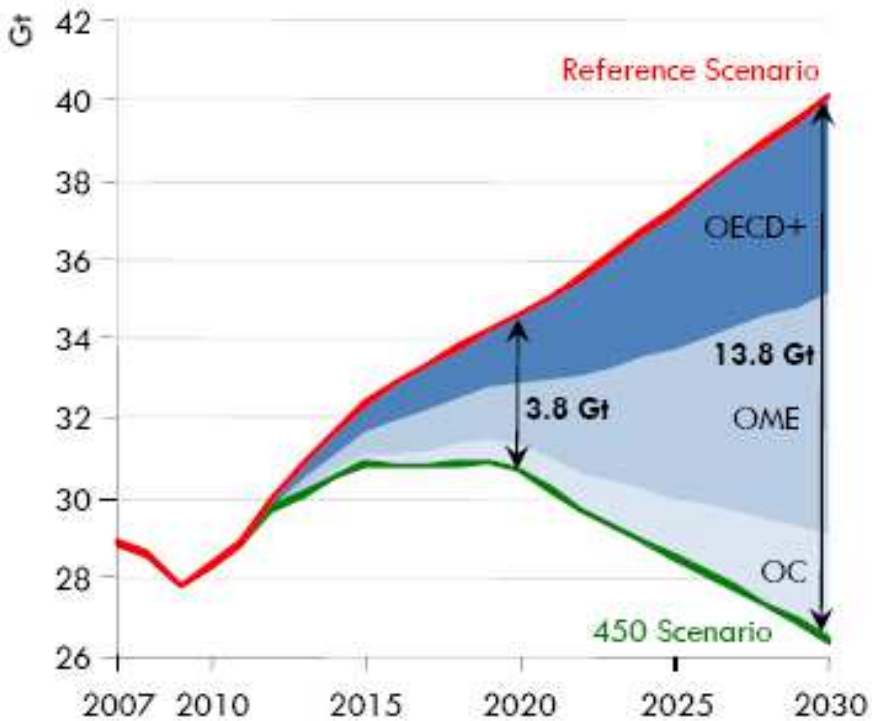
Source: Adapted from Financial Times

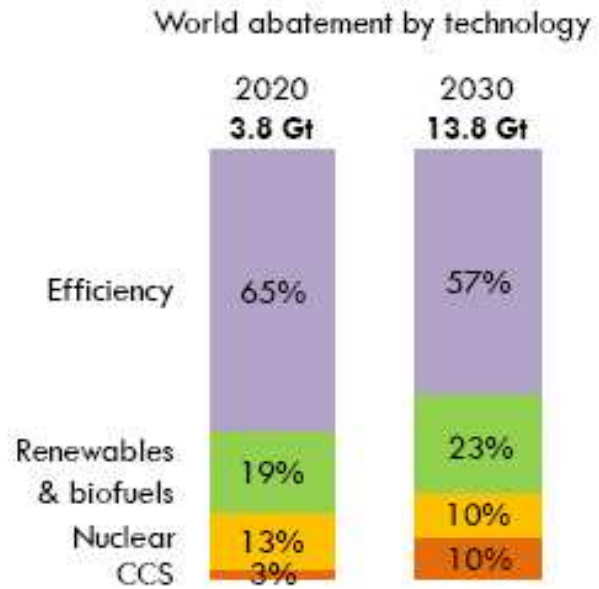


South Korea	Japan	Brazil	India	Russia	EU	China	US
549	1,360	1,014	1,853	2,133	4,193	7,219	7,242
4%	30%	0%	20-24% CO_2 emission intensity reduction	31-38% increase	18-29%	40-45% CO_2 emission intensity reduction	17%

World Energy Outlook 2009

World abatement of energy-related CO_2 emissions in the 450 Scenario



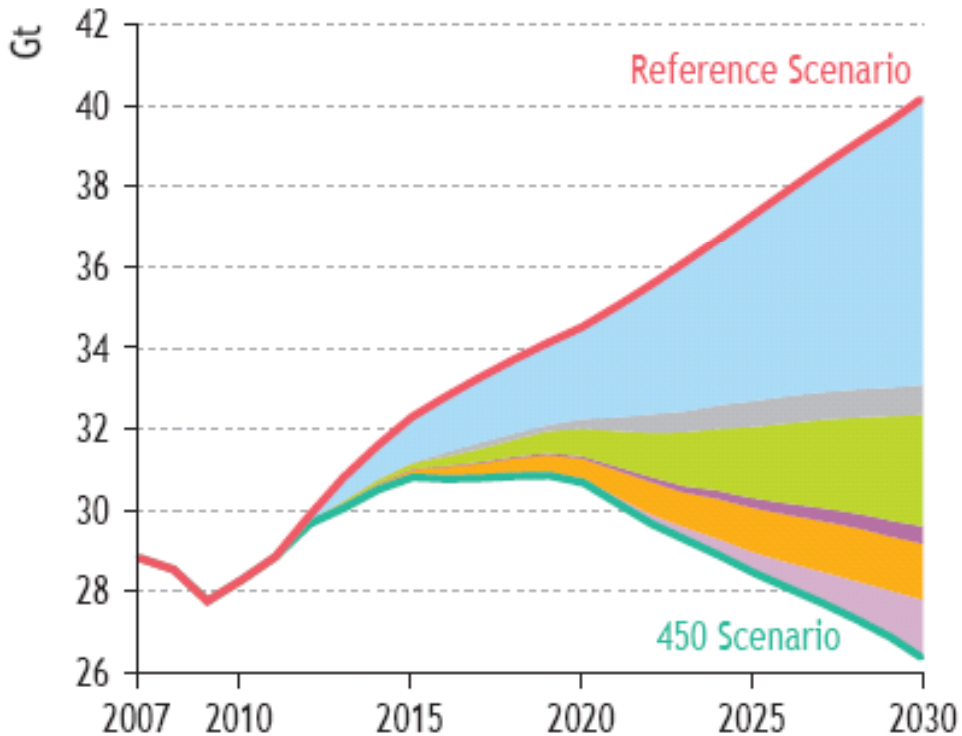


An additional $10.5 trillion of investment is needed in total in the 450 Scenario, with measures to boost energy efficiency accounting for most of the abatement through to 2030

© OECD/IEA - 2009

The Need of CO_2 Capture and Storage in the Power Generation Sector

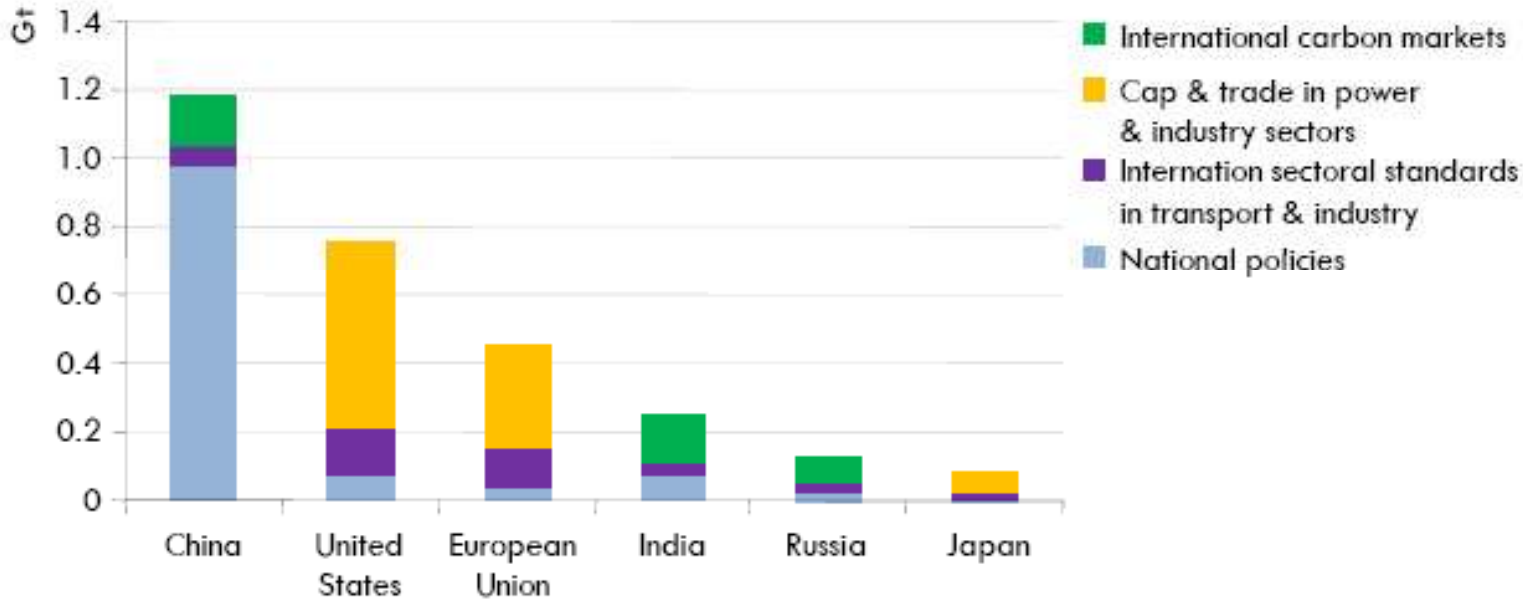
World Energy Outlook (Source: IEA)



	Abatement (Mt CO_2)		Investment ($2008 billion)	
	2020	2030	2010-2020	2021-2030
Efficiency	2 517	7 880	1 999	5 586
End-use	2 284	7 145	1 933	5 551
Power plants	233	735	66	35
Renewables	680	2 741	527	2 260
Biofuels	57	429	27	378
Nuclear	493	1 380	125	491
CCS	102	1 410	56	646

World Energy Outlook 2009

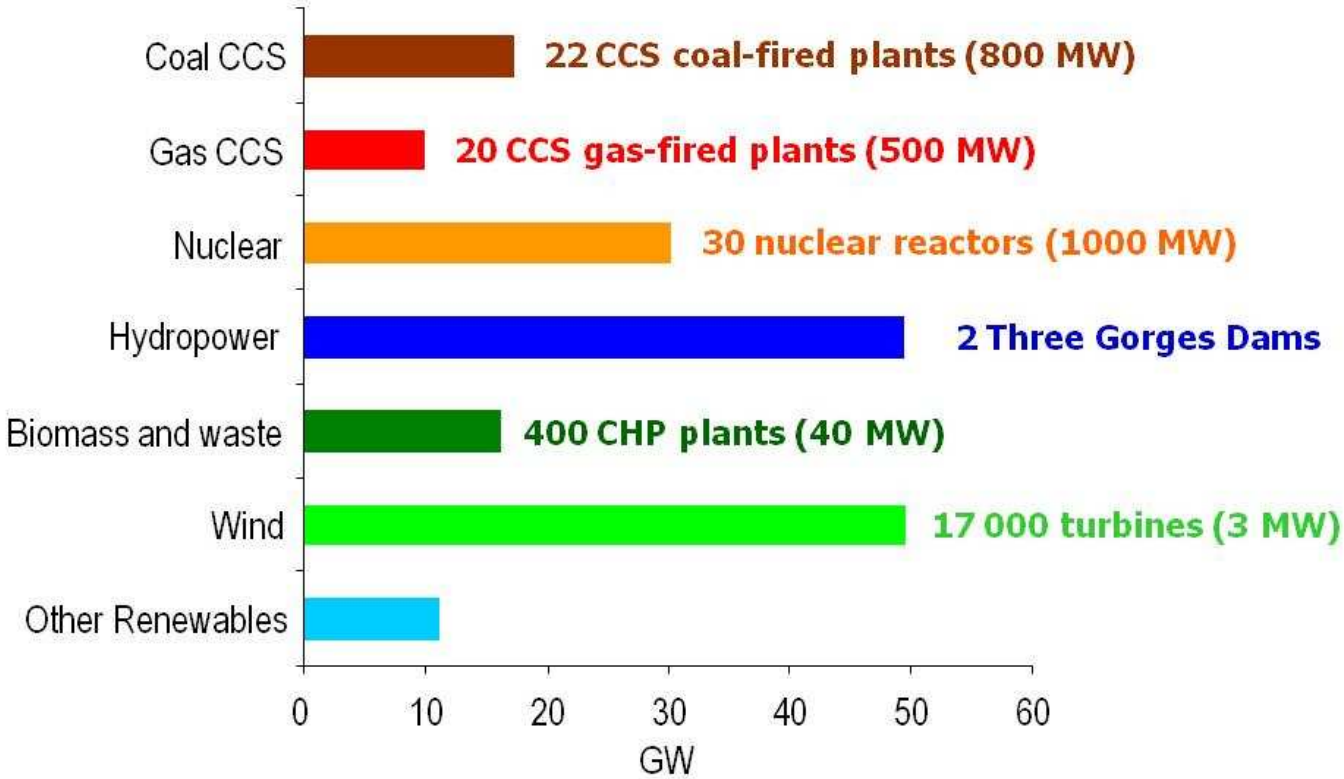
Abatement in the 450 Scenario by key emitters, 2020



China, the United States, the European Union, India, Russia & Japan account for almost three-quarters of the 3.8 Gt reduction in the 450 Scenario

© OECD/IEA - 2009

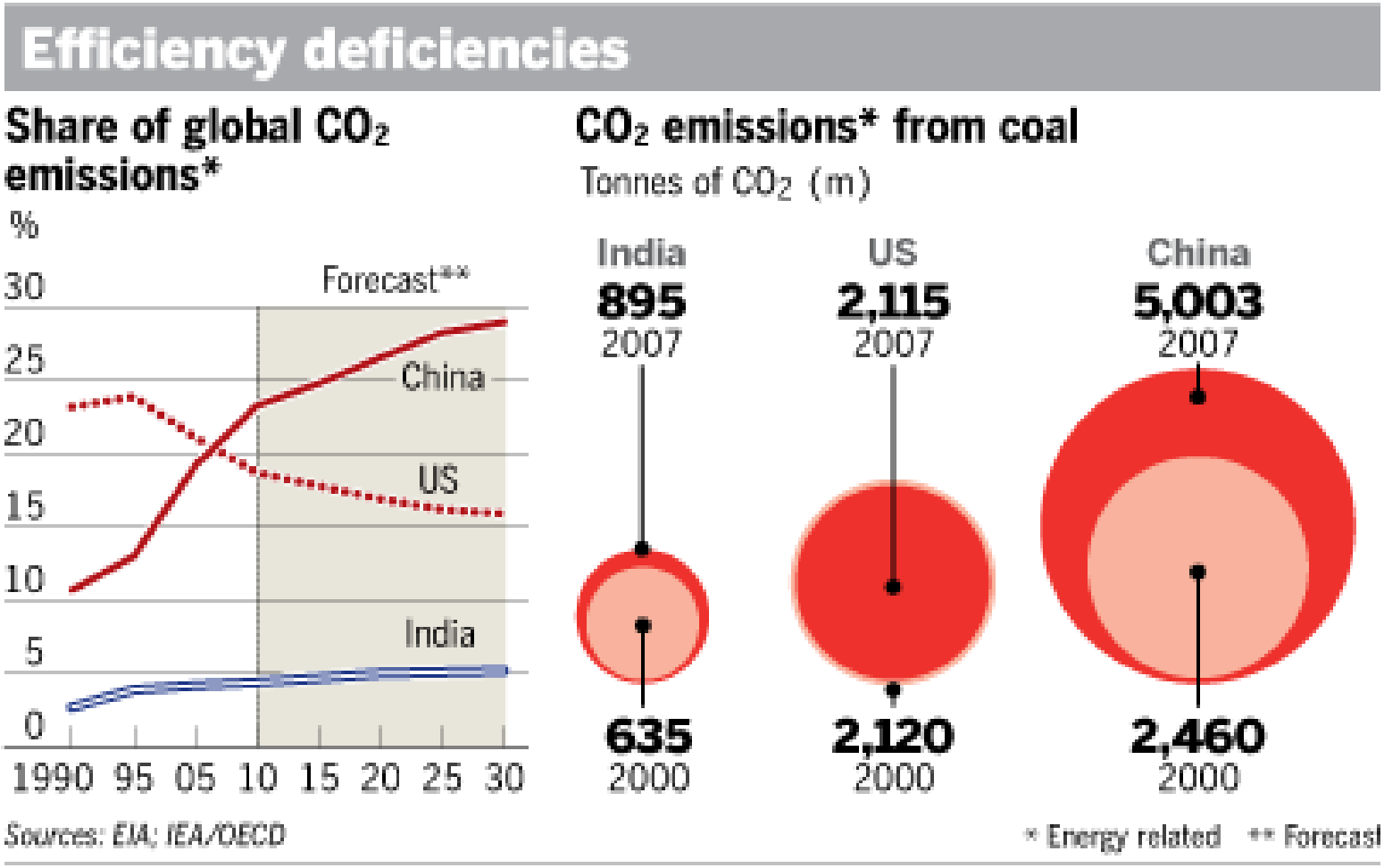
Average Annual Power Generation Capacity Additions in the 450 ppm CO_2 Stabilisation Case, 2013-2030



A large amount of capacity would need to be retired early, entailing substantial costs

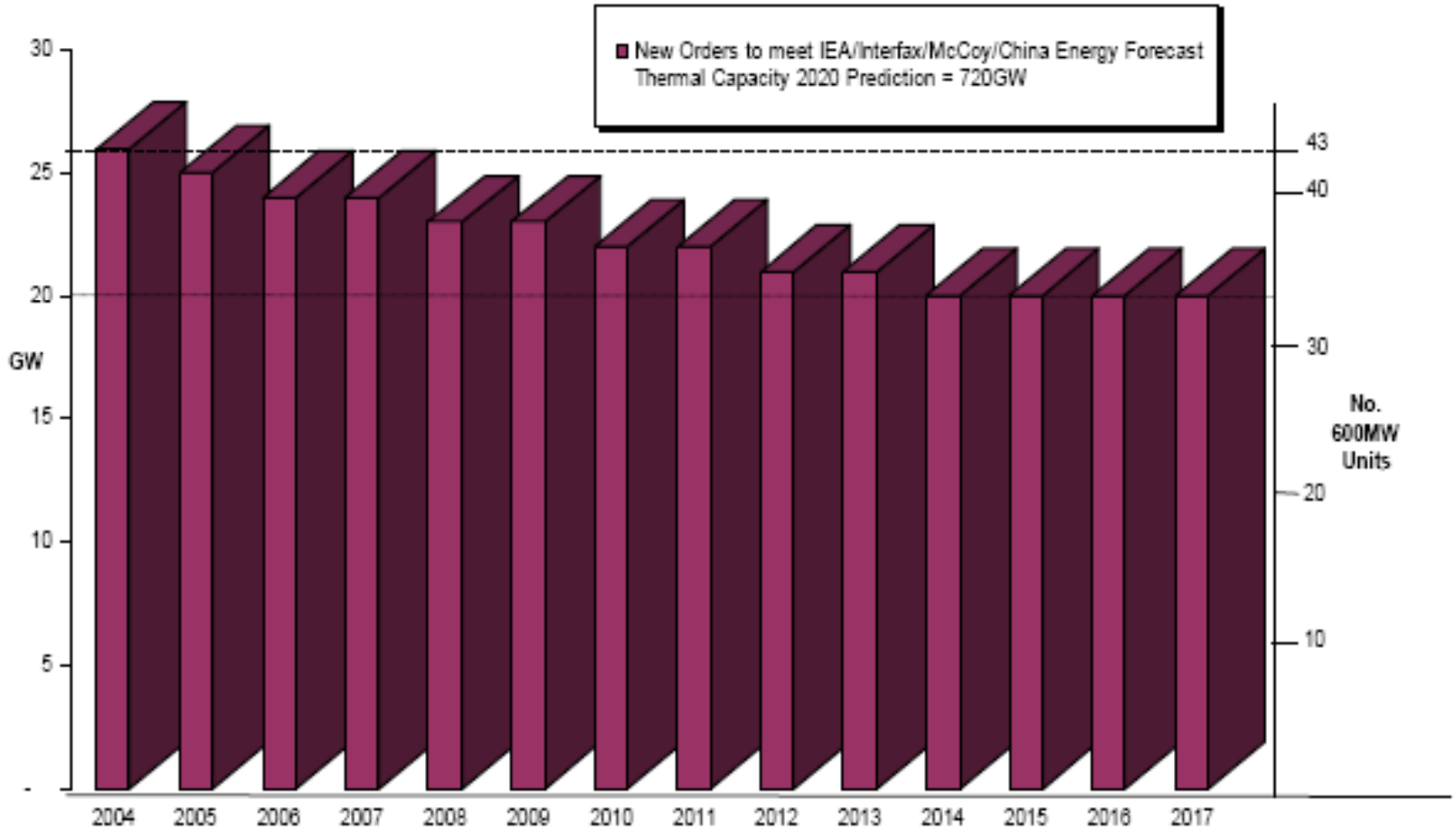
Source: IEA ETP 2008

China & India Factor



China Factor…

They have the youngest and some of the very efficient fleet of coal power plants in the world



China – Unconventional but Effective

THE STRAITS TIMES, THURSDAY, DECEMBER 4, 199

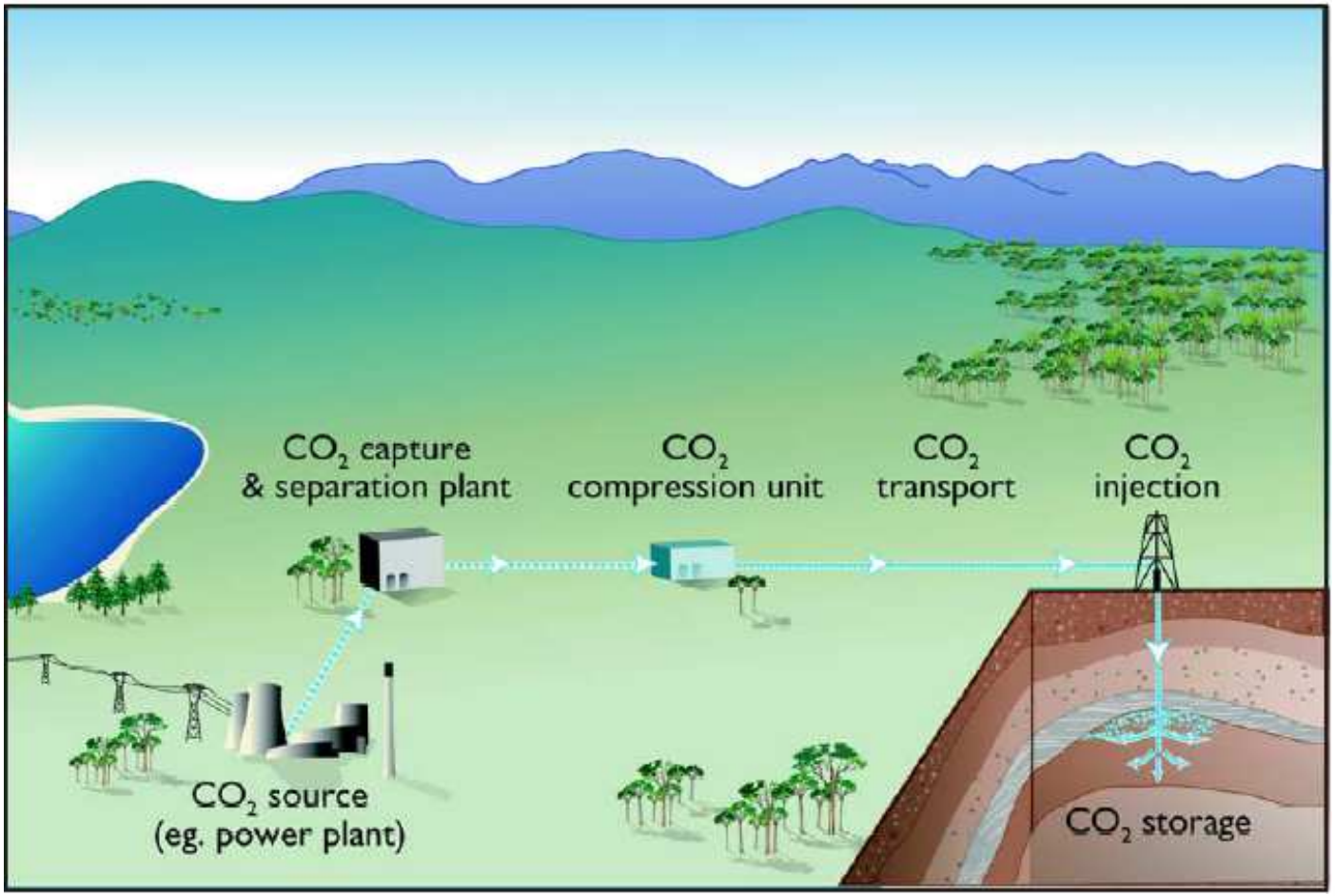
EAST ASIA

Gas what they stole?

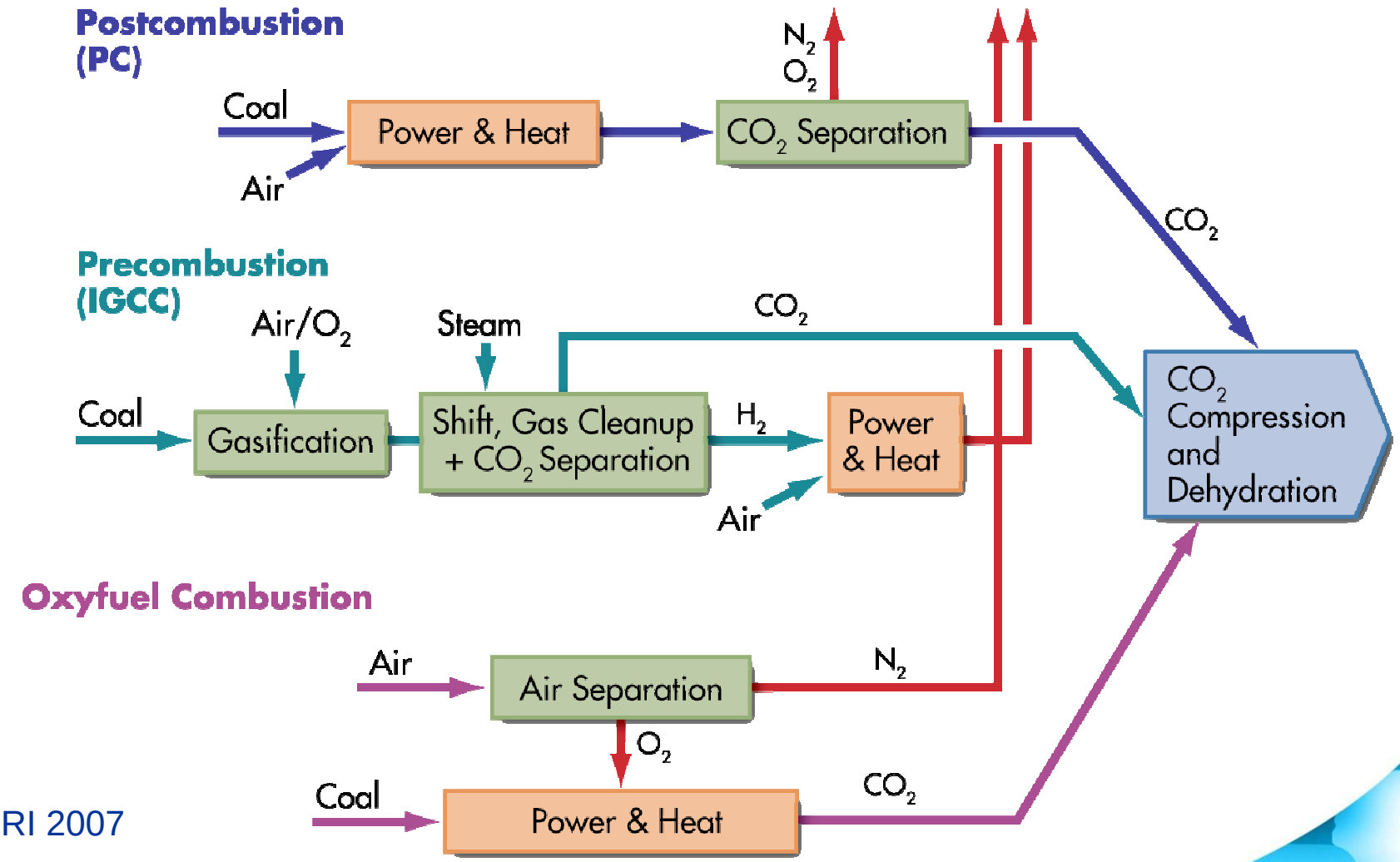
CHINESE farmers near the Zhongyuan oil fields in Henan province transporting giant plastic bags filled with stolen natural gas which they use for heating and cooking. Oil companies suffer annual losses of more than 20 million yuan (S$3.9 million) to theft. —AFP picture.

CO_2 CAPTURE AND STORAGE OVERVIEW

CO_2 Capture and Storage (Full Chain)



CO_2 Capture Options



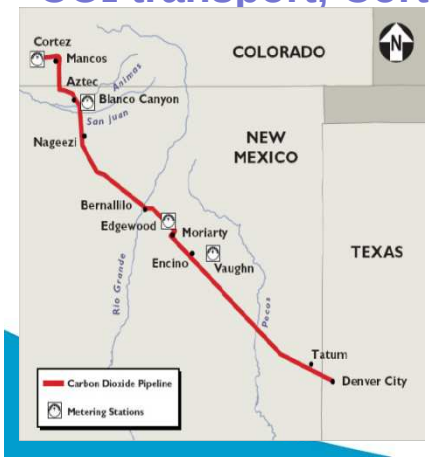
EPRI 2007

CO_2 Transport Option

Mode of Transport

- Pipeline
- Motor Trucks
- Rail
- Ocean-going ships

CO_2 transport, Cortez pipeline

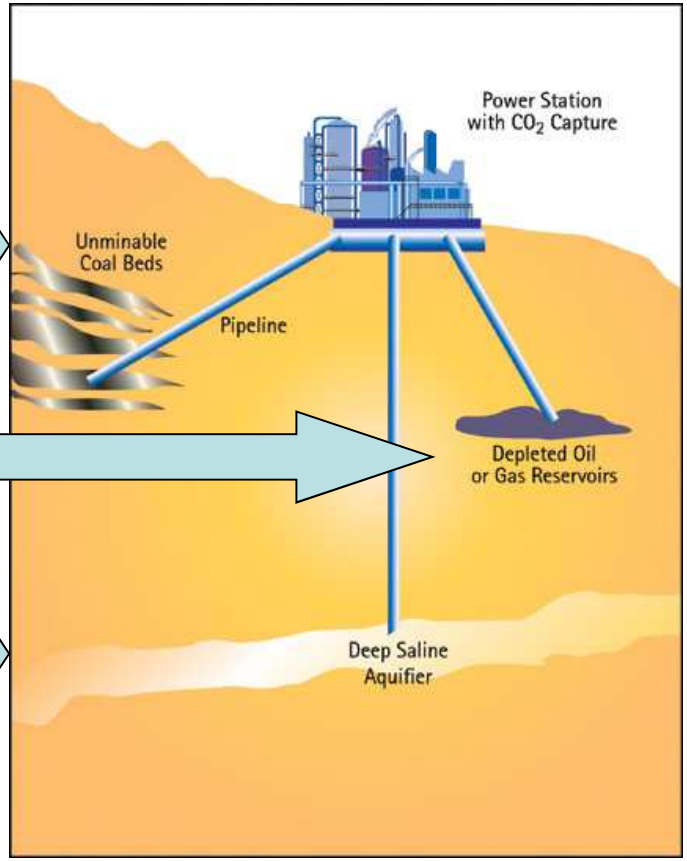


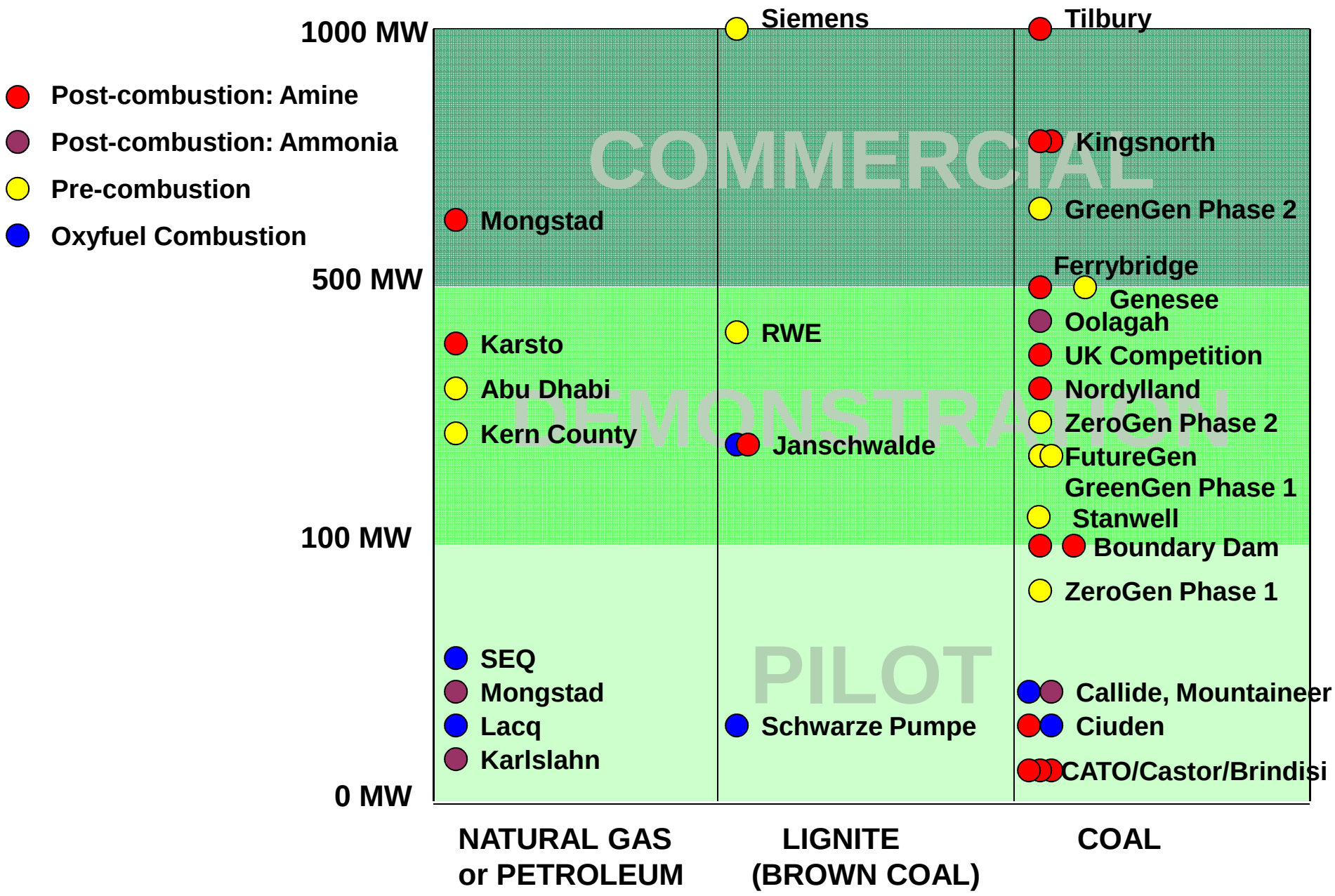
Geological Storage Options

Unminable Coal Seams
30 Gt CO_2
Able to store <2 Years of 2030 Emissions

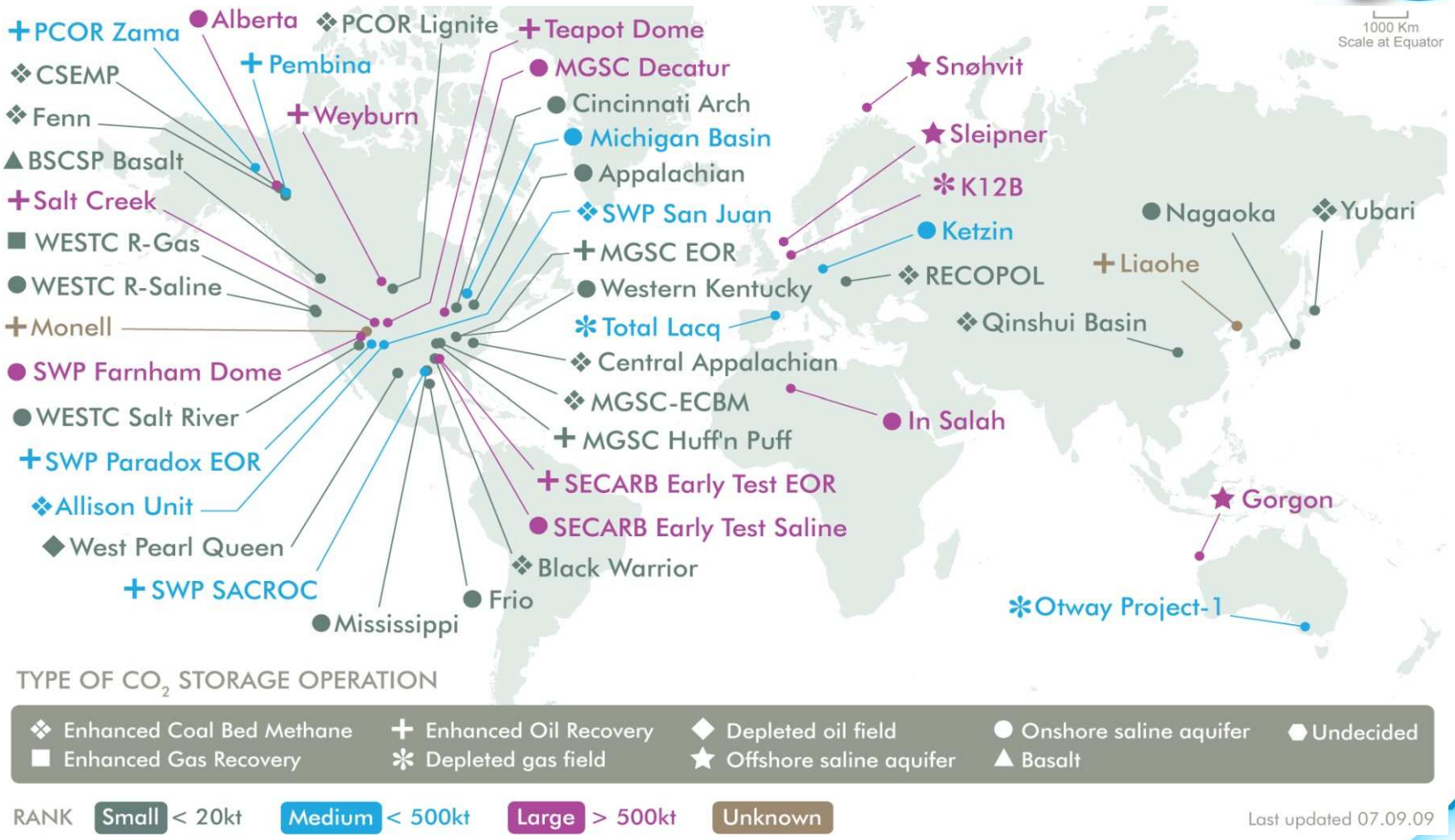
Depleted Oil & Gas Fields
930 Gt CO_2
Able to Store 50 Years of 2030 Emissions

Deep Saline Aquifers
400-10 000 Gt CO_2
Able to store 20 - 530 Years of 2030 Emissions




Post-combustion: Amine
Post-combustion: Ammonia
Pre-combustion
Oxyfuel Combustion
1000 MW
500 MW
100 MW
0 MW
COMMERCIAL
DEMONSTRATION
PILOT
Mongstad
Karsto
Abu Dhabi
Kern County
SEQ
Mongstad
Lacq
Karlslahn
Siemens
RWE
Janschwalde
Schwarze Pumpe
Tilbury
Kingsnorth
GreenGen Phase 2
Ferrybridge
Genesee
Oolagah
UK Competition
Nordylland
ZeroGen Phase 2
FutureGen
GreenGen Phase 1
Stanwell
Boundary Dam
ZeroGen Phase 1
Callide, Mountaineer
Ciuden
CATO/Castor/Brindisi
NATURAL GAS
or PETROLEUM
LIGNITE
(BROWN COAL)
COAL

Current CCS Projects



Source: CO2CRC

Key Message: Moving to demonstration

- ***Full scale demonstration of CCS is needed to establish confidence in the technology***
- ***The G8 have set the goal of 20 demonstration projects by 2020***
- ***The IEA CCS Road Map has set out the case for 100 demonstration projects by 2020 and 3000 by 2050.***

CHALLENGES TO CO_2 CAPTURE AND STORAGE

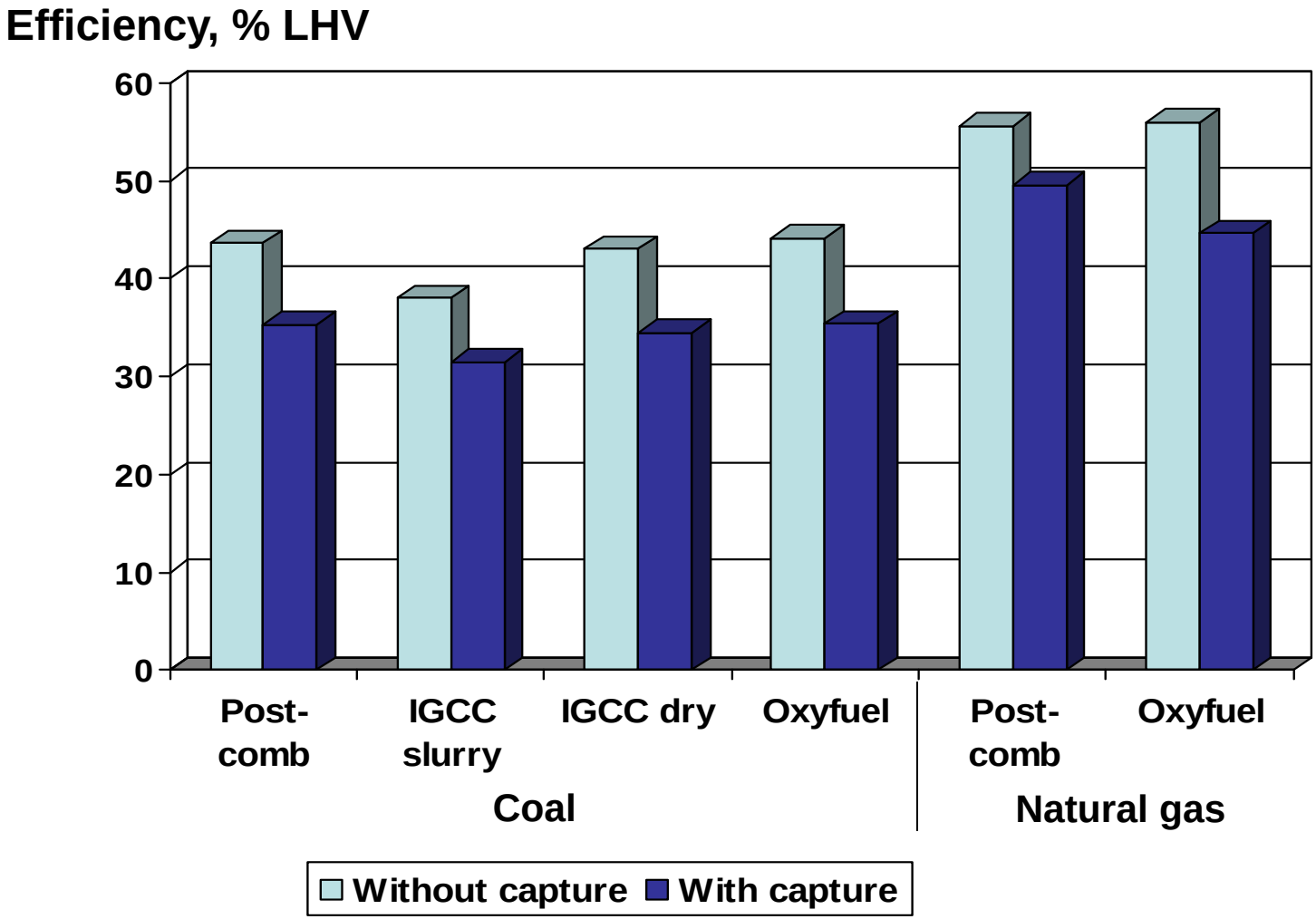
Energy Efficiency Penalty
(CO_2 Capture)

- ***Adding CCS to a power plant will result in a reduction in power plant efficiency of between 4 and 10%***

- ***Development of CCS in the power sector must go hand in hand with increased efficiency – EC policy***

- ***<u>IEA GHG advocate deploying CCS only on the most efficient power plant</u>***
  - Coal plant (state of art)
    - 47% LHV (sea water cooling)
    - 43% LHV on lignite
    - Higher temperatures will take to 50% LHV
  - Gas Fired plant (state of art)
    - 58% LHV
    - New turbine designs will take this to 60% LHV

Power Generation Efficiency

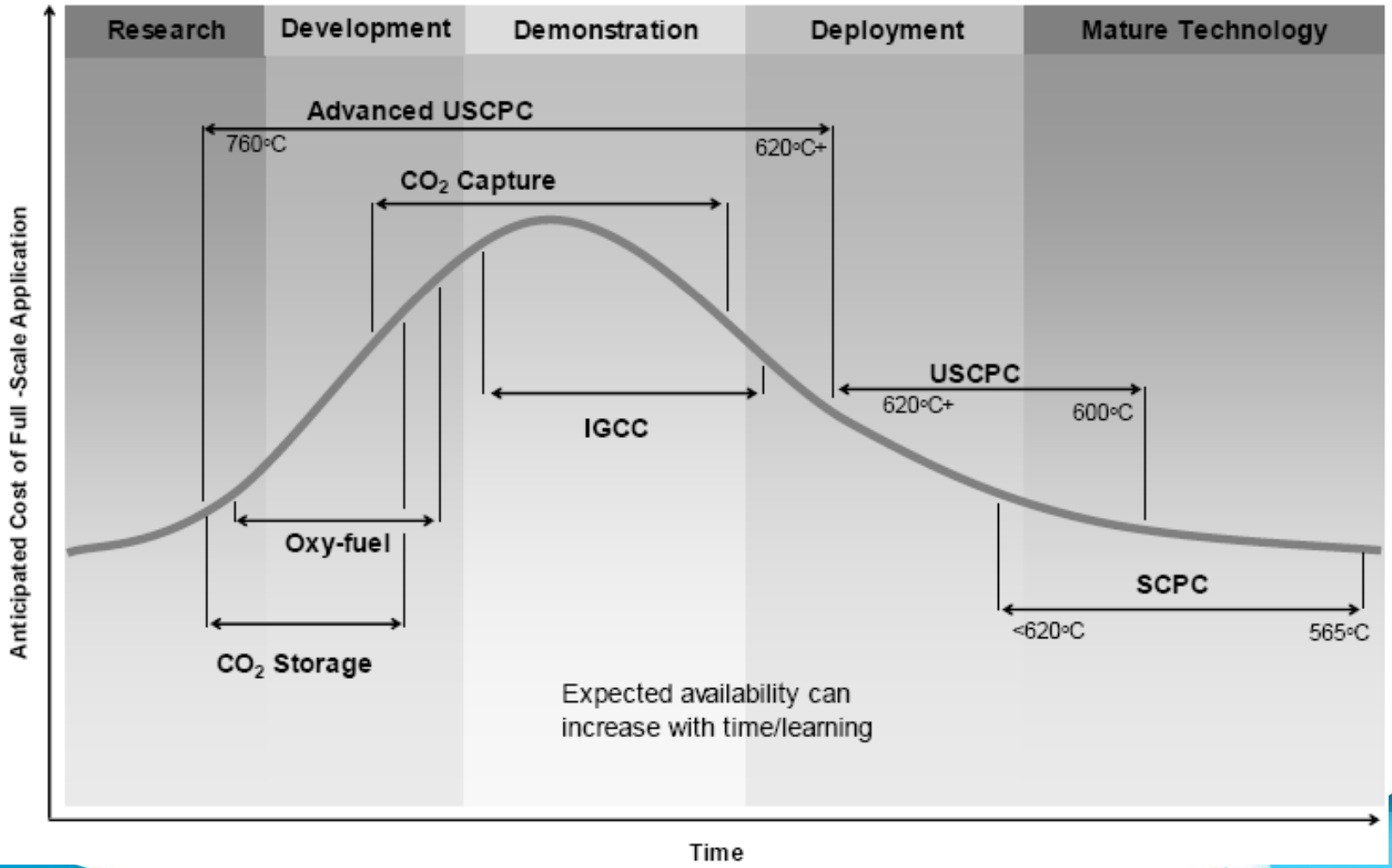


Source: IEA GHG studies

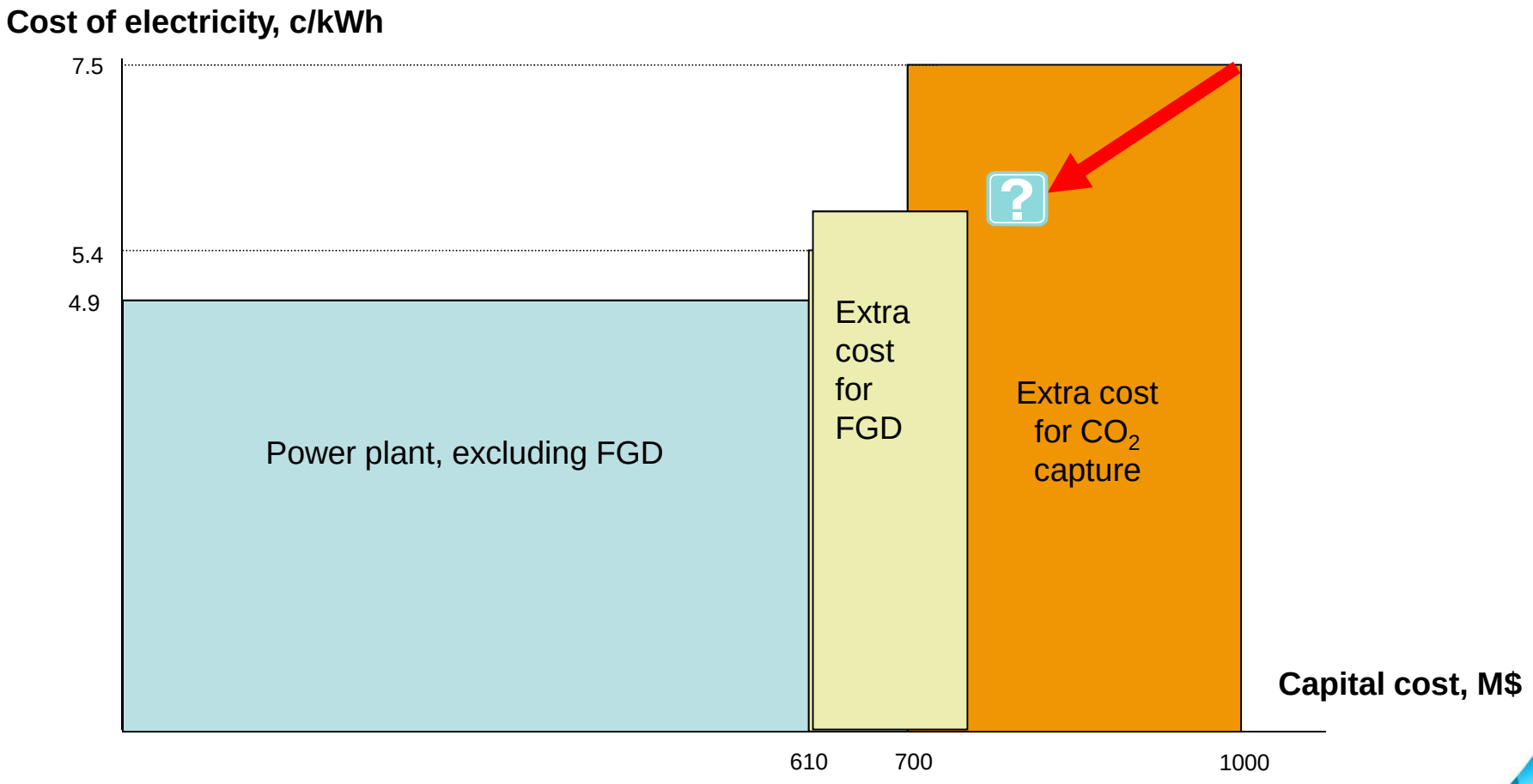
Challenges – Cost of CO_2 Capture

- Currently capture costs about 75% of CCS project costs
- Studies by IEA GHG on plant replication have indicated that costs could decrease by 10-40%
- Technology developments could drive this lower – EC R&D targeting 70% reduction
- Offsetting this is the increase in equipment /labour costs seen in the last 2 years have raised plant costs by 7-20%

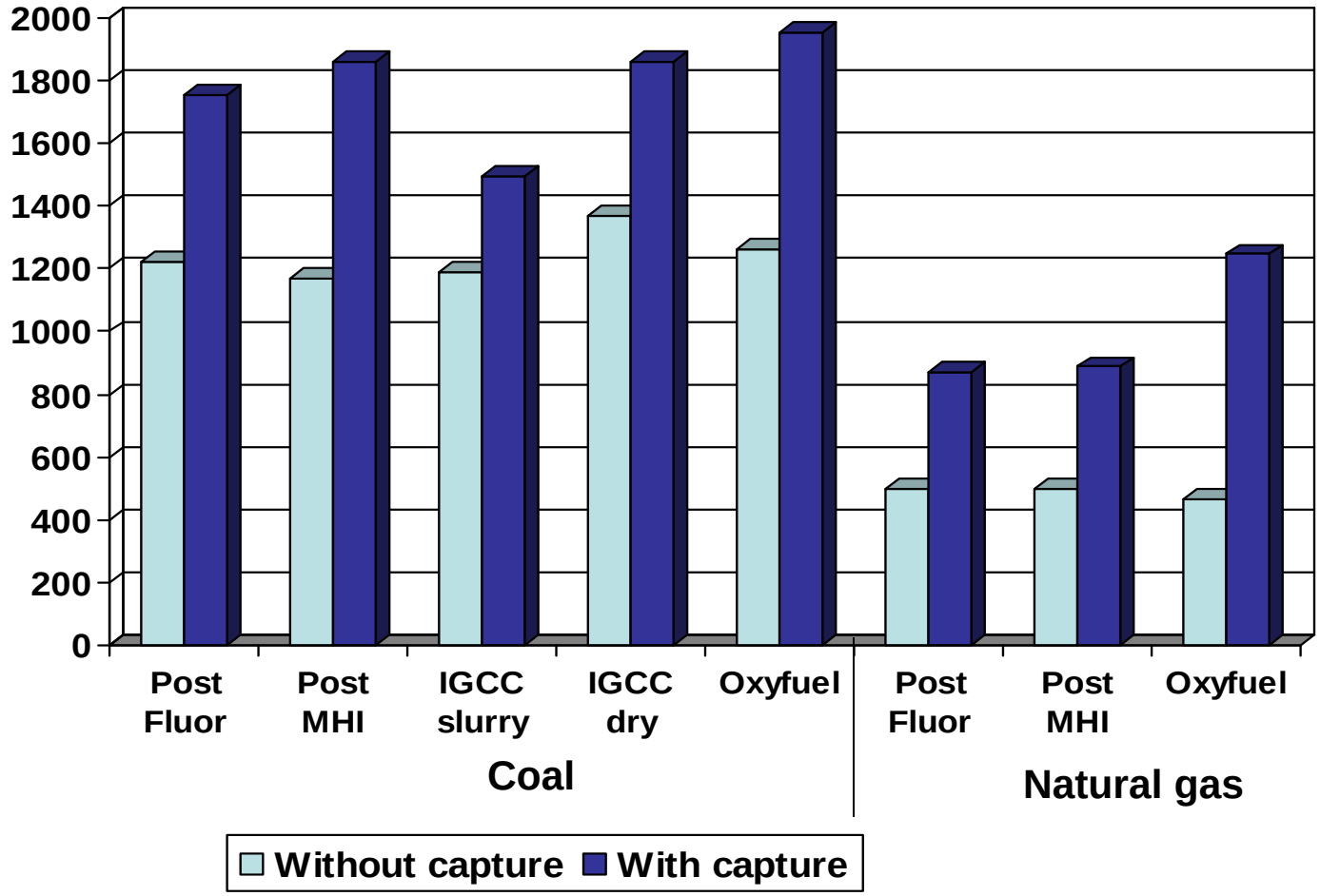
Development Cost of CCT and CO2 Capture Technologies



New 500MW Power Plants



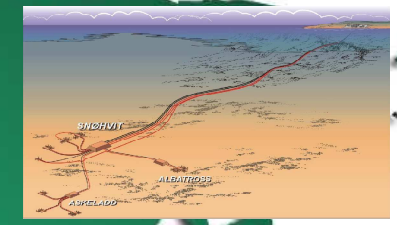
Capital Cost



Based on 1 US $/Euro
Source: IEA GHG studies

35

Challenges – CO2 Transport



Snohvit 160km Sub sea pipeline

CO 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

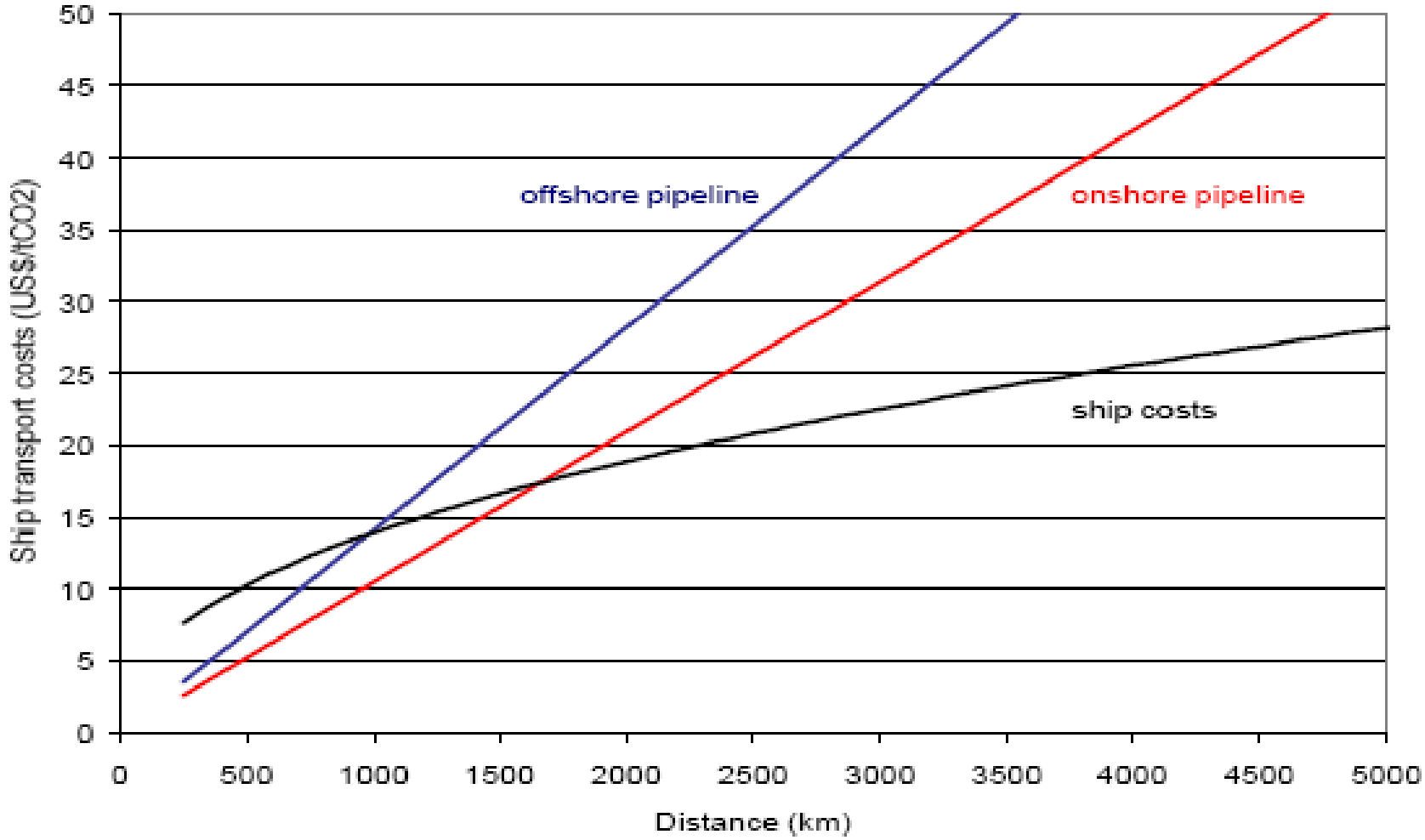
Weyburn 300km transboundary pipeline

Long distance transport of CO_2 by pipeline is established technology

Challenges

- ***Financing the infrastructure***
  - Government?
  - Industry?
- ***Allowing unrestricted access***
- ***Avoiding filling up nearest reservoirs first***
- ***Impacts of impurities***
- ***Gas blends?***
- ***Monitoring and liability for leakage?***

CO_2 Transport Cost
(Data from IPCC Report)



Challenges – Geological Storage

- ***Long term monitoring needs?***
- ***Storage capacity – is there enough?***
- ***Need to rely on aquifers***
  - Addressing security
  - Pressurisation impacts?
  - Brine displacement/water contamination?

CO_2 Storage Cost Curves
(Net Storage Cost)

Region	*Storage cost range $/t CO_2*	*Mean storage cost $/t CO_2*
Europe	*1 to 80*	*2.5*
North America	*-13 to 37*	*12*

Significant cost difference observed

Public Engagement
(Geological Storage)

- ***Need to learn from both positive and adverse experiences***
  - US study from Regional Partnerships Programme
  - Barendrecht, the Netherlands
- ***Communications research network established by GCCSI and IEAGHG***
  - Aims to share experiences and establish best practise guidelines

Finances

- ***Government finance needed to support demonstration projects***
  - Australia, Clean Energy Initiatives Programme
    - CCS Flagship Program
      - A$2.0 billion to fund 2 – 4 industrial-scale CCS projects
  - Canada,C$1 billion clean energy fund
    - Alberta has earmarked C$2 billion for CCS projects
  - USA
    - $1bn for CCS projects, $1bn for FutureGen and $1bn for industrial CCS projects
  - European Energy Recovery Programme
    - €1 billion to six CCS projects

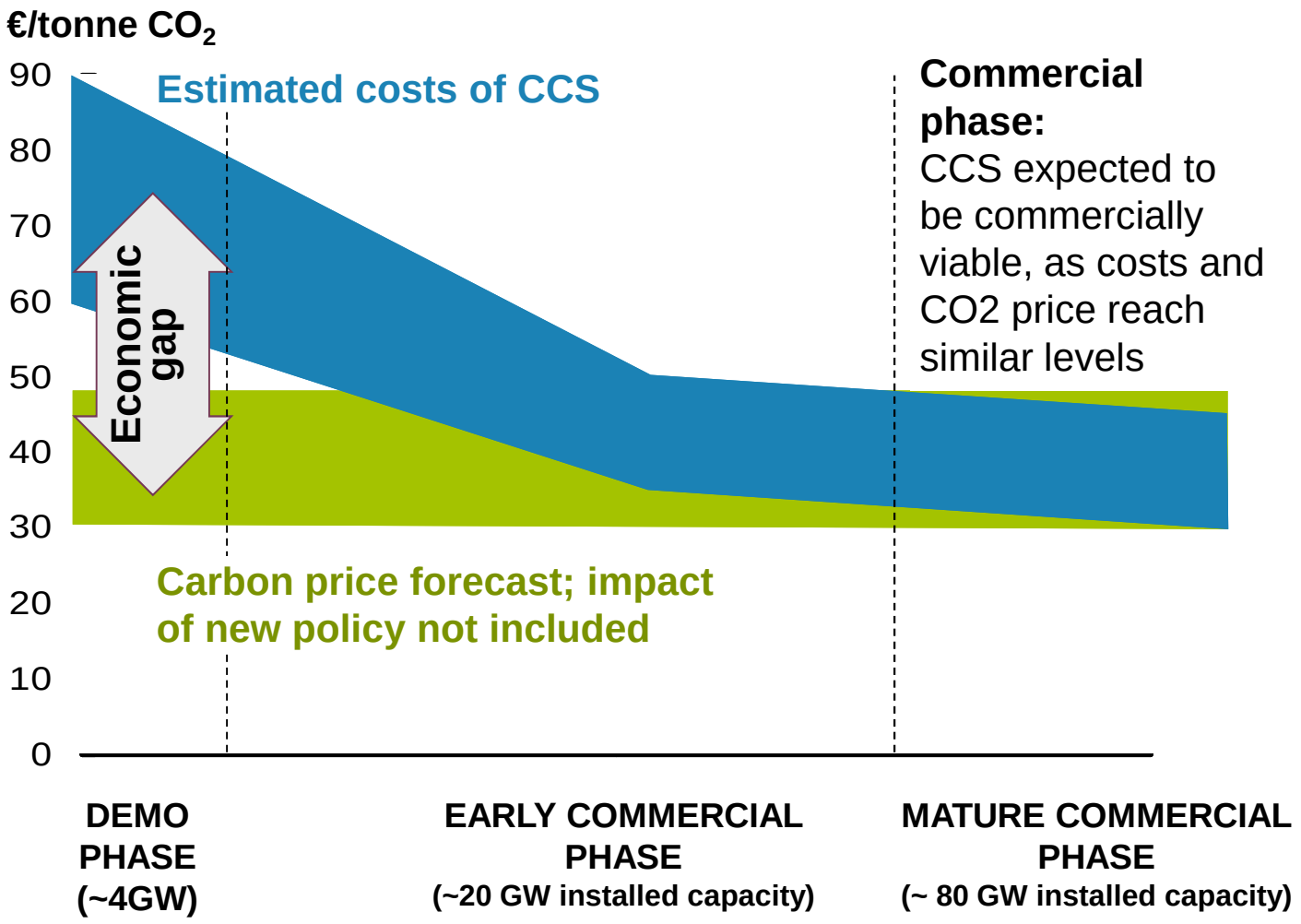
Towards a CO2 cost: current status of ETS developments with the worlds top 5 CO2 emitters shown bold

Country	Situation
USA	**ETS unlikely to pass Congress, President likely to change options**
China	**No ETS**
Japan	**ETS planned**
India	**No ETS**
Australia	ETS not likely to pass Senate, extensive debate and other options emerging
Canada	No ETS, awaiting USA developments
New Zealand	Only non-EU ETS, operating with fixed carbon cost to 2013
EU, 27 countries	ETS in operation as the EU Greenhouse Gas Emission Trading Scheme
Russia	**No ETS**

THE UNIVERSITY OF NEWCASTLE AUSTRALIA

Demonstration Phase Requires Funding to Fill the Economic Gap

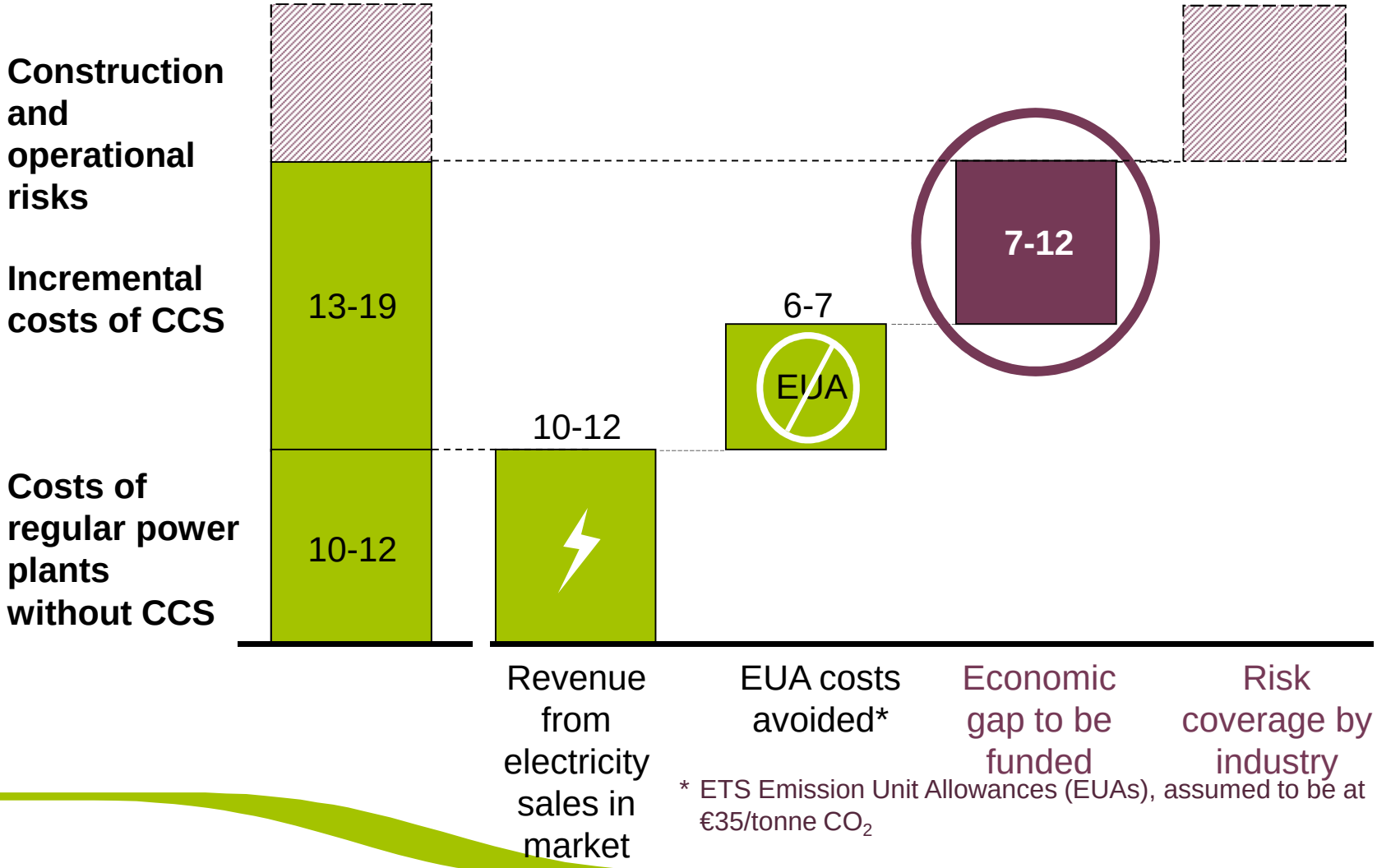
Demonstration phase:
CCS not economically viable. Public contribution necessary for some portion



Commercial phase:
CCS expected to be commercially viable, as costs and CO2 price reach similar levels

10-12 Demonstration Projects within EU = €7 Billion - €12 Billion in Funding

Present value over lifetime, € billion



* ETS Emission Unit Allowances (EUAs), assumed to be at €35/tonne CO_2

Challenges – Policy level

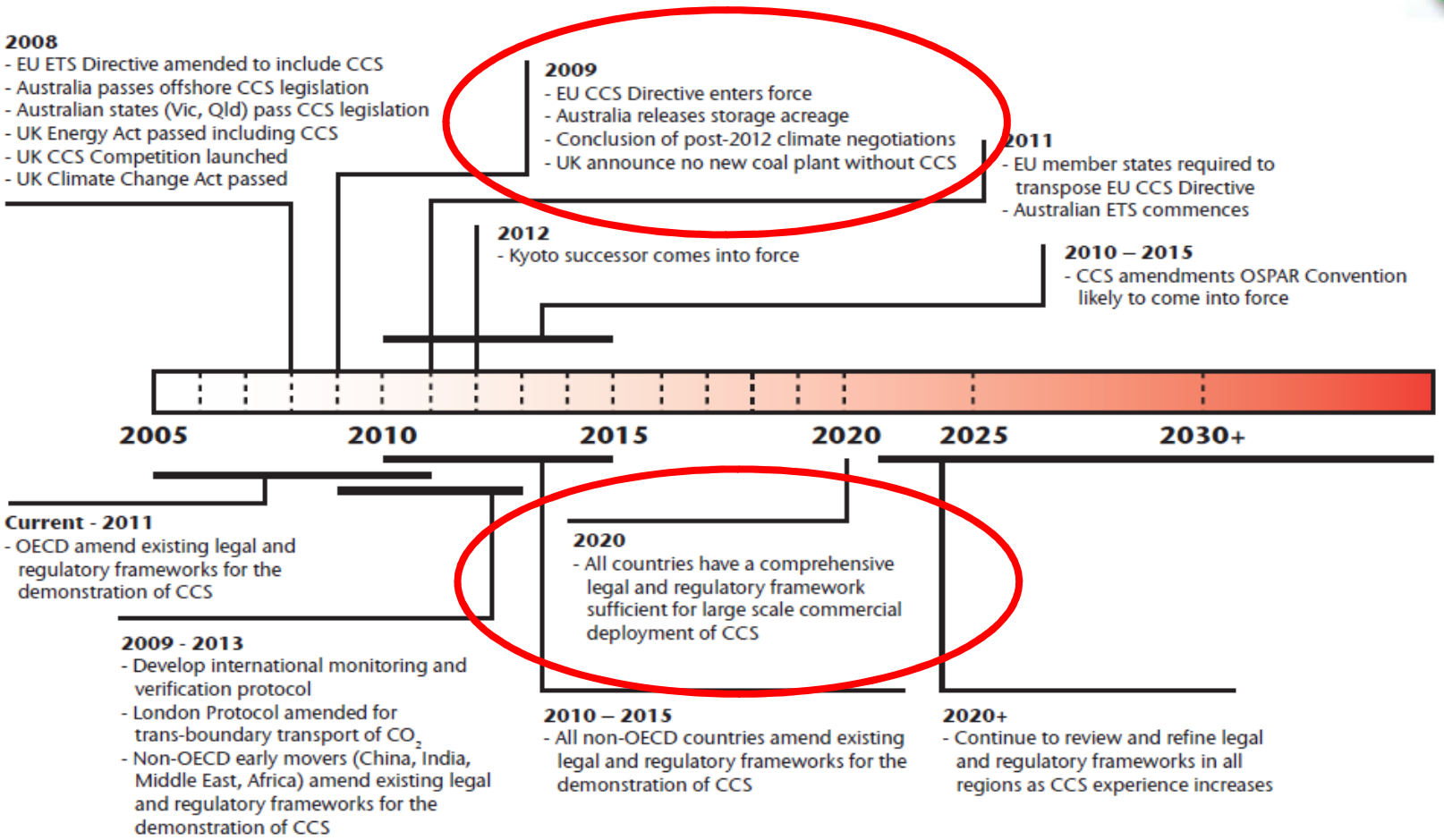
- ***Establishing regulatory frameworks***
- ***Financing early demonstration***
  - Need Governmental support
- ***Gaining public support***
  - “No to Clean Coal” lobby

Regulatory Frameworks

- ***Existing legal and regulatory frameworks should be reviewed and adapted for CCS demonstration by 2011 in OECD countries and by 2015 in all countries***
- ***All countries should have a legal and regulatory framework suitable for large-scale CCS deployment by 2020***
- ***International legal issues need to be resolved by 2012***

Source: IEA CCS Technology Roadmap 2009

Milestones



Source: IEA CCS Technology Roadmap 2009

Future Challenges

- ***Need to find routes to unblock delays with demonstration projects***
  - Permitting issues
  - Rights of way
- ***Need to gain public support for CCS***
- ***Need financial mechanism for support in developing countries***
  - CDM
  - Replaced by Copenhagen “Green Fund”

SUMMARY AND CONCLUDING REMARKS

Concluding Remarks in General

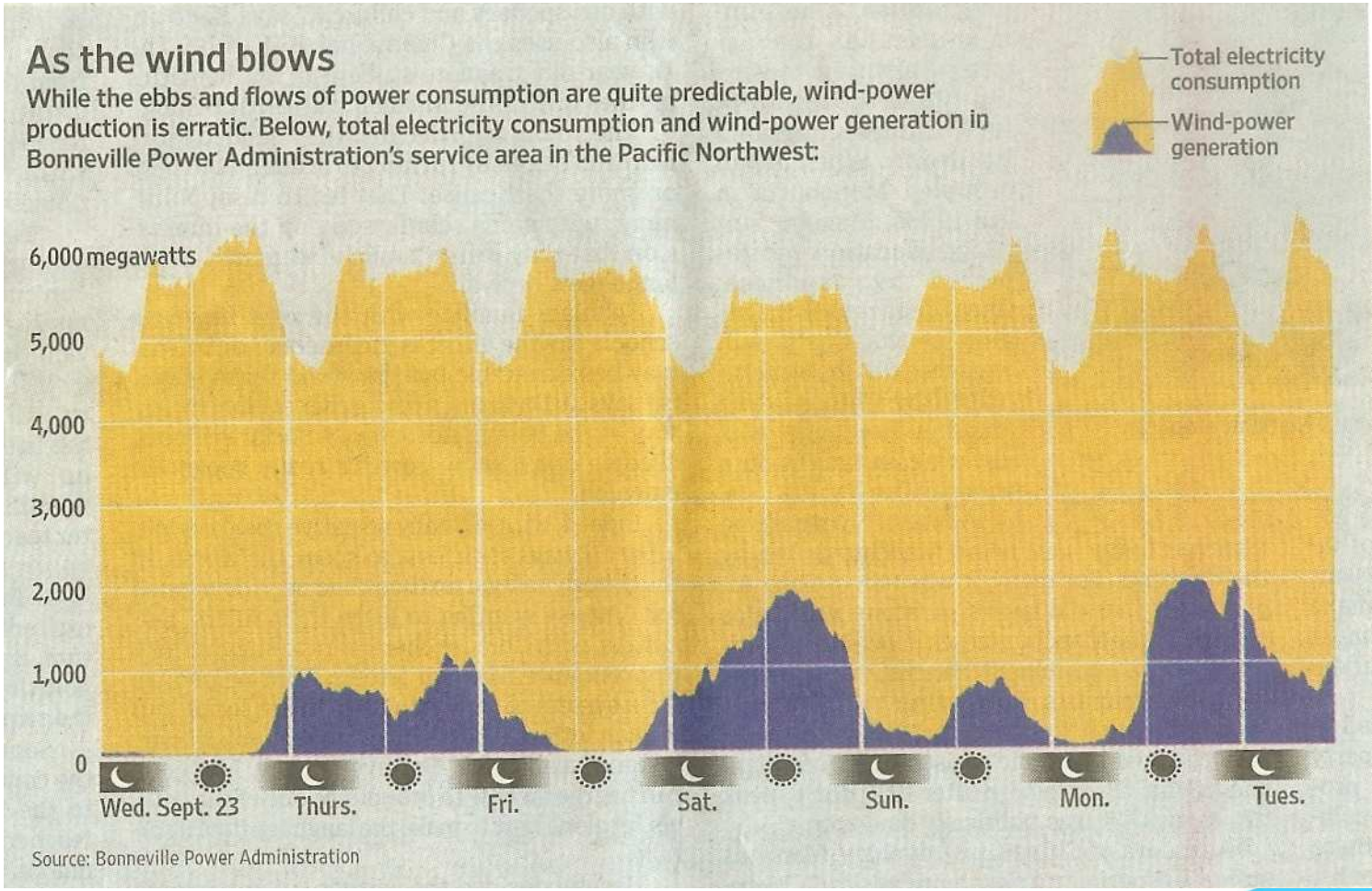
- ***The world needs CCS***
- ***CCS is not in competition with alternatives***
- ***There are no technical show stoppers to CCS implementation***
- ***There is need for "Technology learning-by-doing" to make CCS successful in terms of cost effectiveness in a normal business operation***
- ***Possible shows stoppers are the legal, economic, financial and public acceptance.***

Concluding Remarks in Specific Terms

- ***Technology has come a long way in 20 years***
- ***Demonstration of CCS is crucial in next 10 years***
- ***Must win public hearts and minds***
- ***Must move past demonstration quickly into widespread implementation***
- ***Need mechanism to support CCS in developing countries***

Thank you

Email: ***stanley.santos@ieaghg.org***

Website: ***http://www.ieaghg.org***

Challenges of Renewable Energy