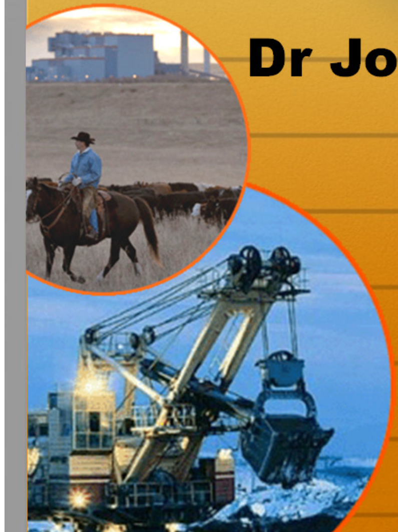
Coal demand World-Wide & the role of Clean Coal Technologies and CCS

Dr John Topper, CEO IEA Coal Research Ltd, UK



BusinessNZ Energy Council

Wellington, 29 October 2013

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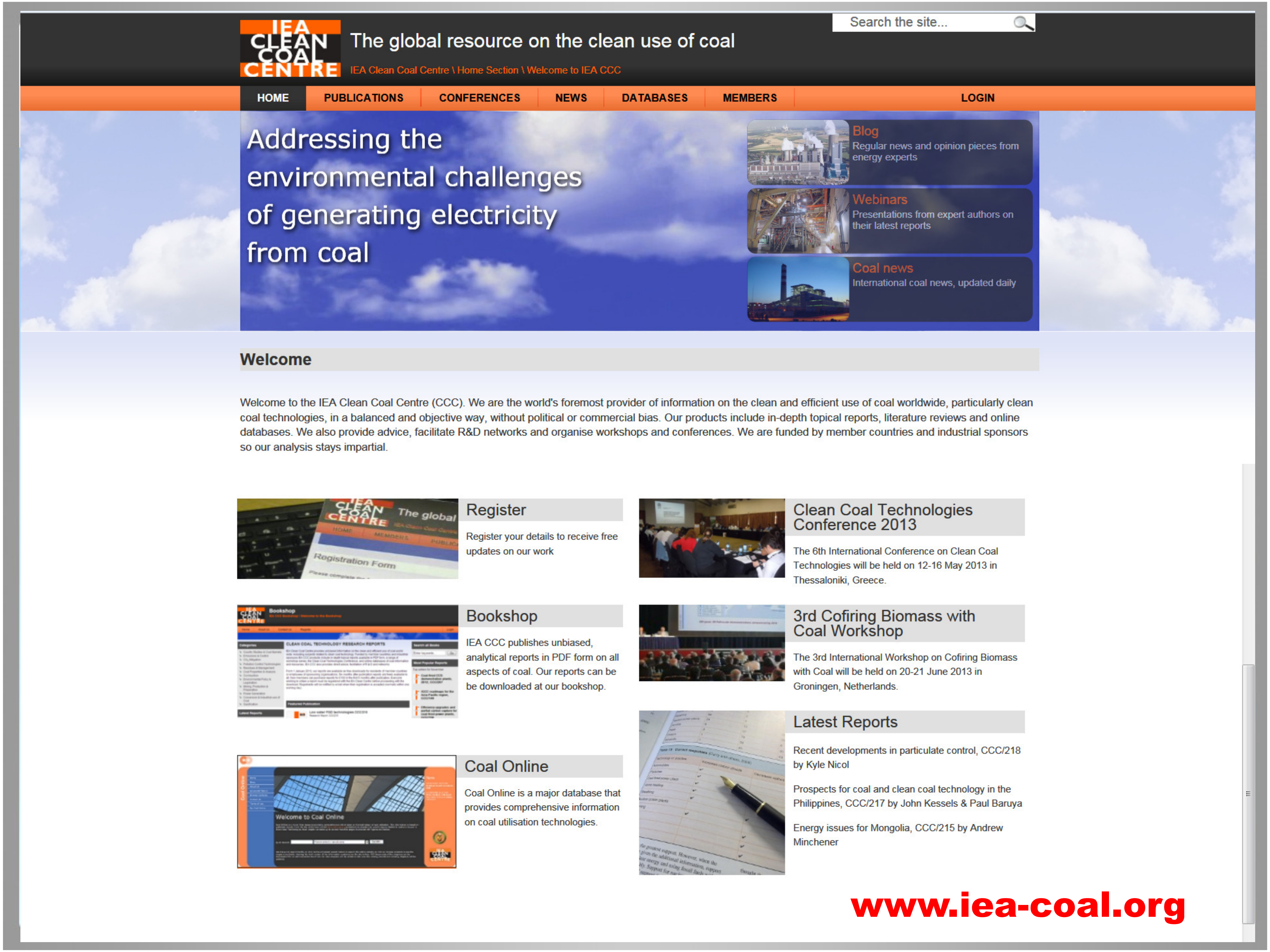
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Contents

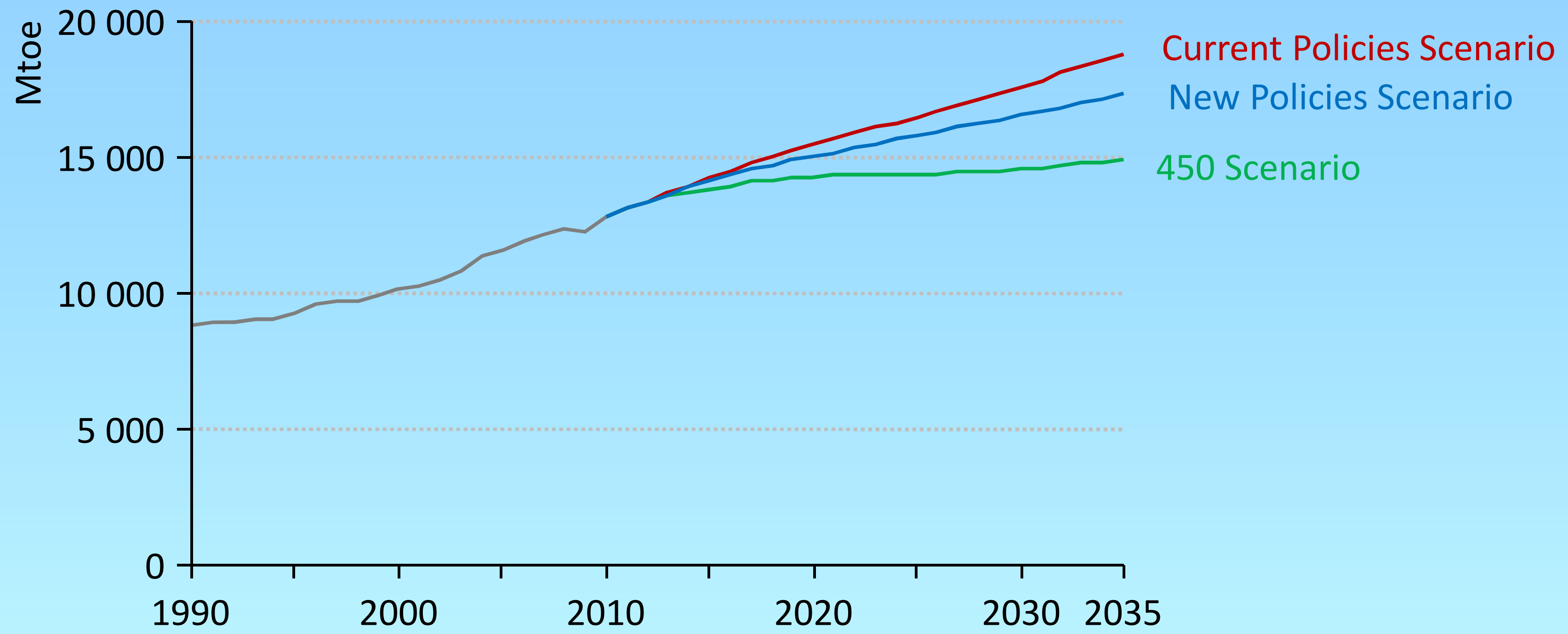
- IEA World Energy Outlook 2012 – coal aspects
- IEA High Efficiency Low Emissions Coal Power
- Coal and biomass
- Status of carbon capture technology development

World Energy Outlook

Published by IEA November 2012

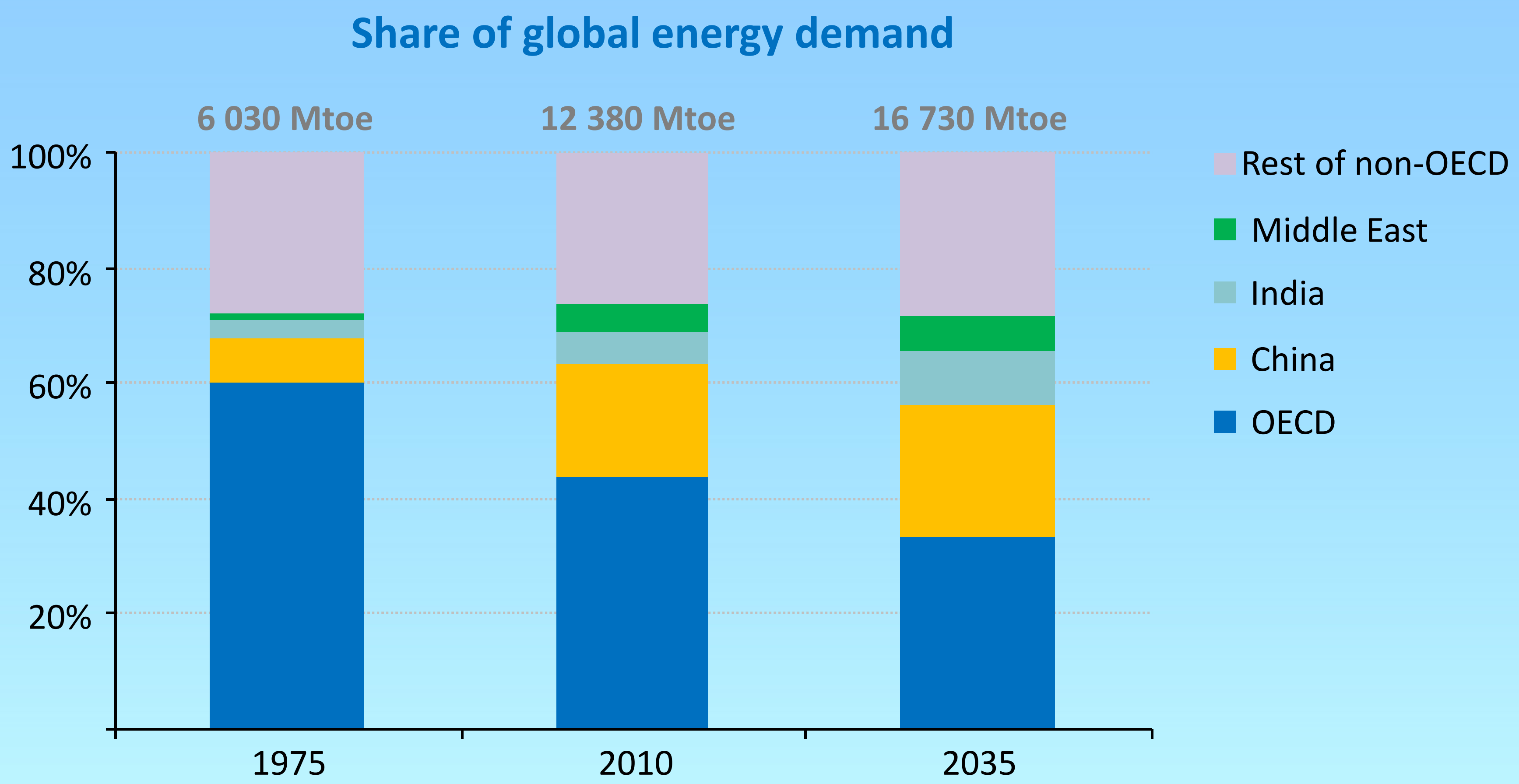
All views expressed are the speaker's and not necessarily the IEA's

IEA WEO 2012
World primary energy demand by scenario



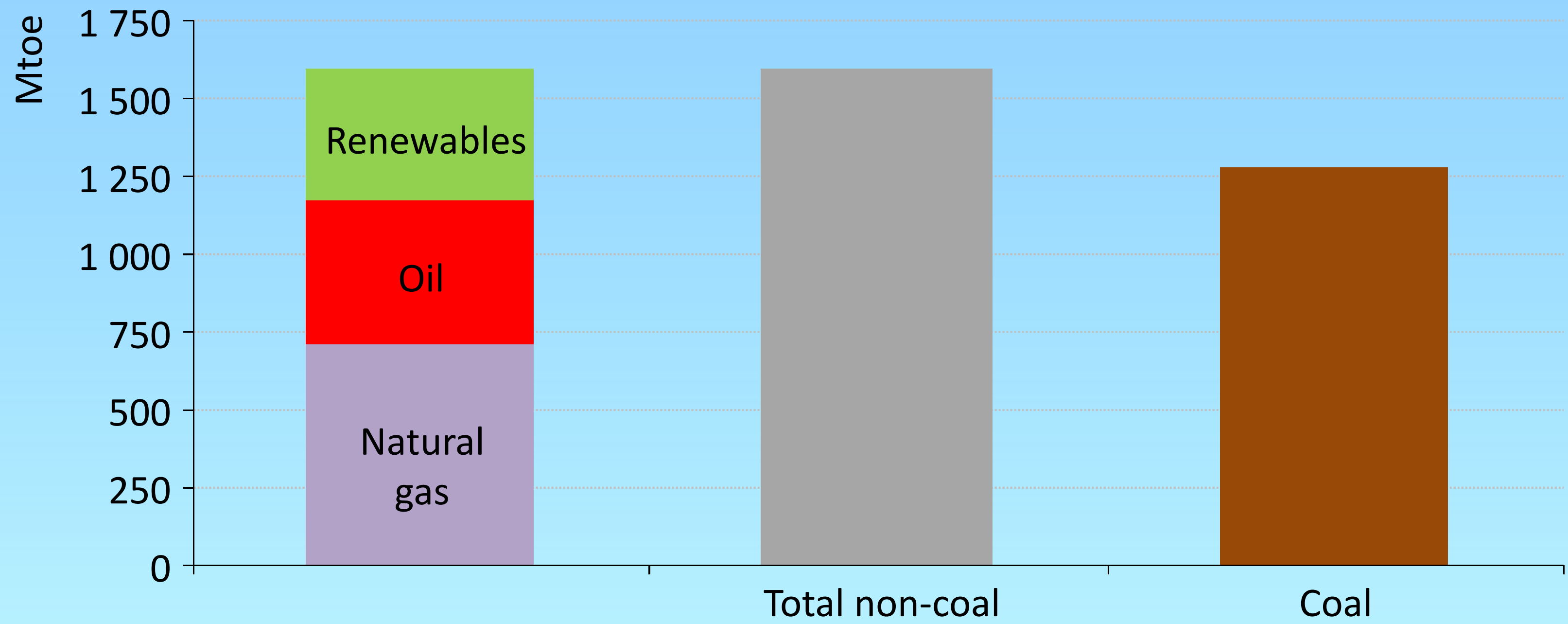
Energy demand rises by over one-third in 2010-2035 in the New Policies Scenario, underpinned by rising living standards in emerging economies

IEA WEO 2012
Emerging economies steer energy markets



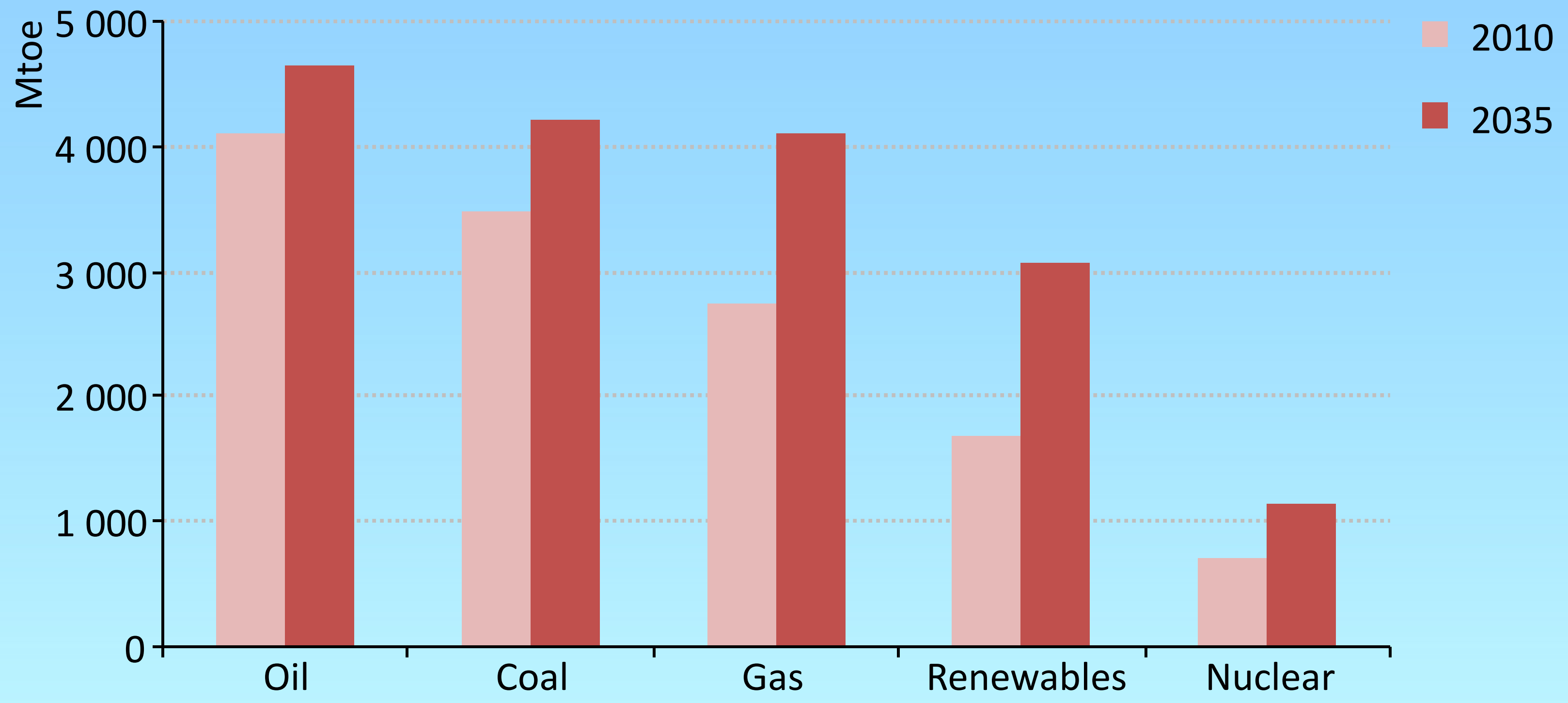
Global energy demand rises by over one-third in the period to 2035, underpinned by rising living standards in China, India & the Middle East

IEA WEO 2012
Incremental world primary energy demand by fuel, 2001-2011



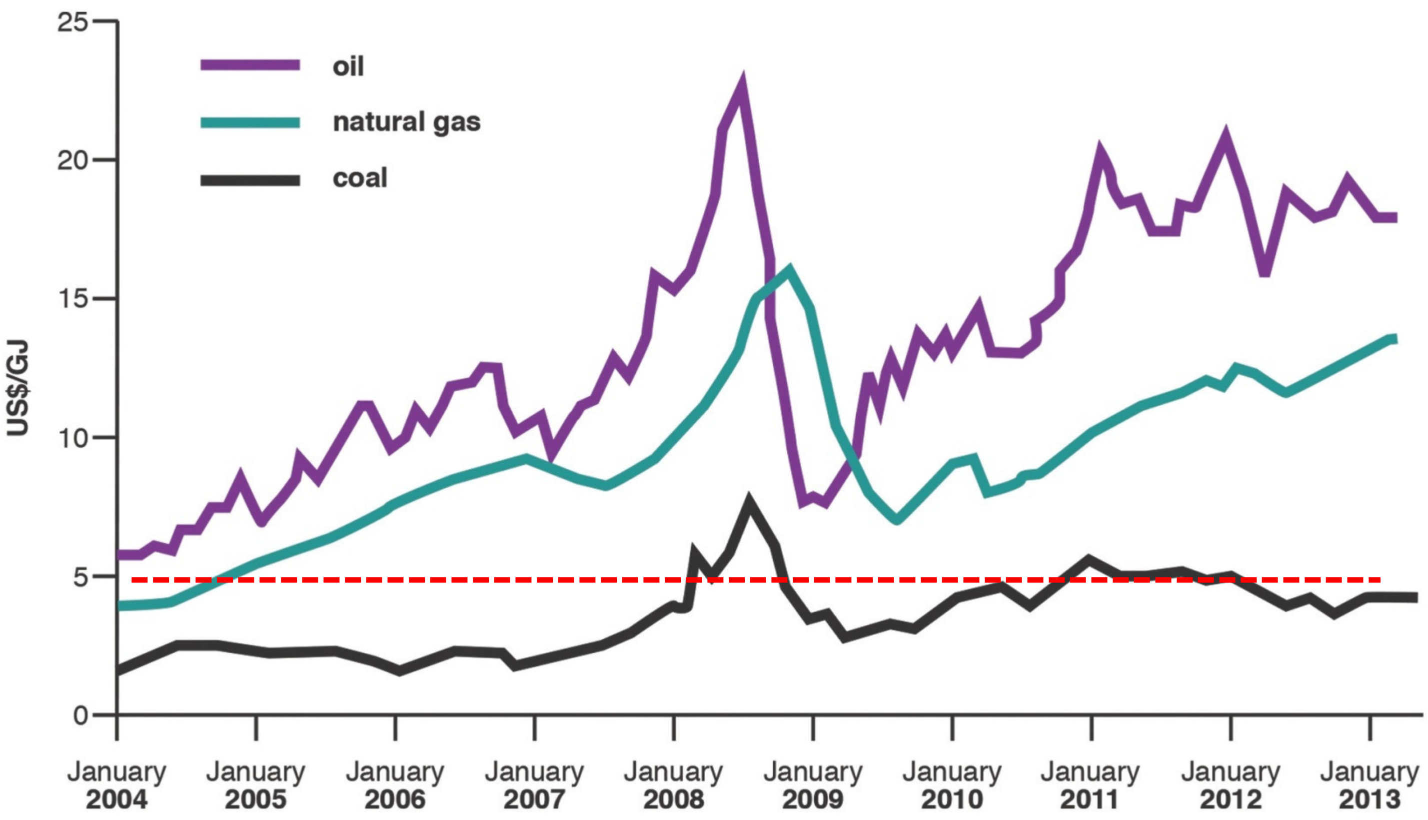
Since the start of the 21st century, coal has dominated the global energy demand picture, alone accounting for 45% of energy demand growth over 2001-2011

IEA WEO 2012
World primary energy demand by fuel

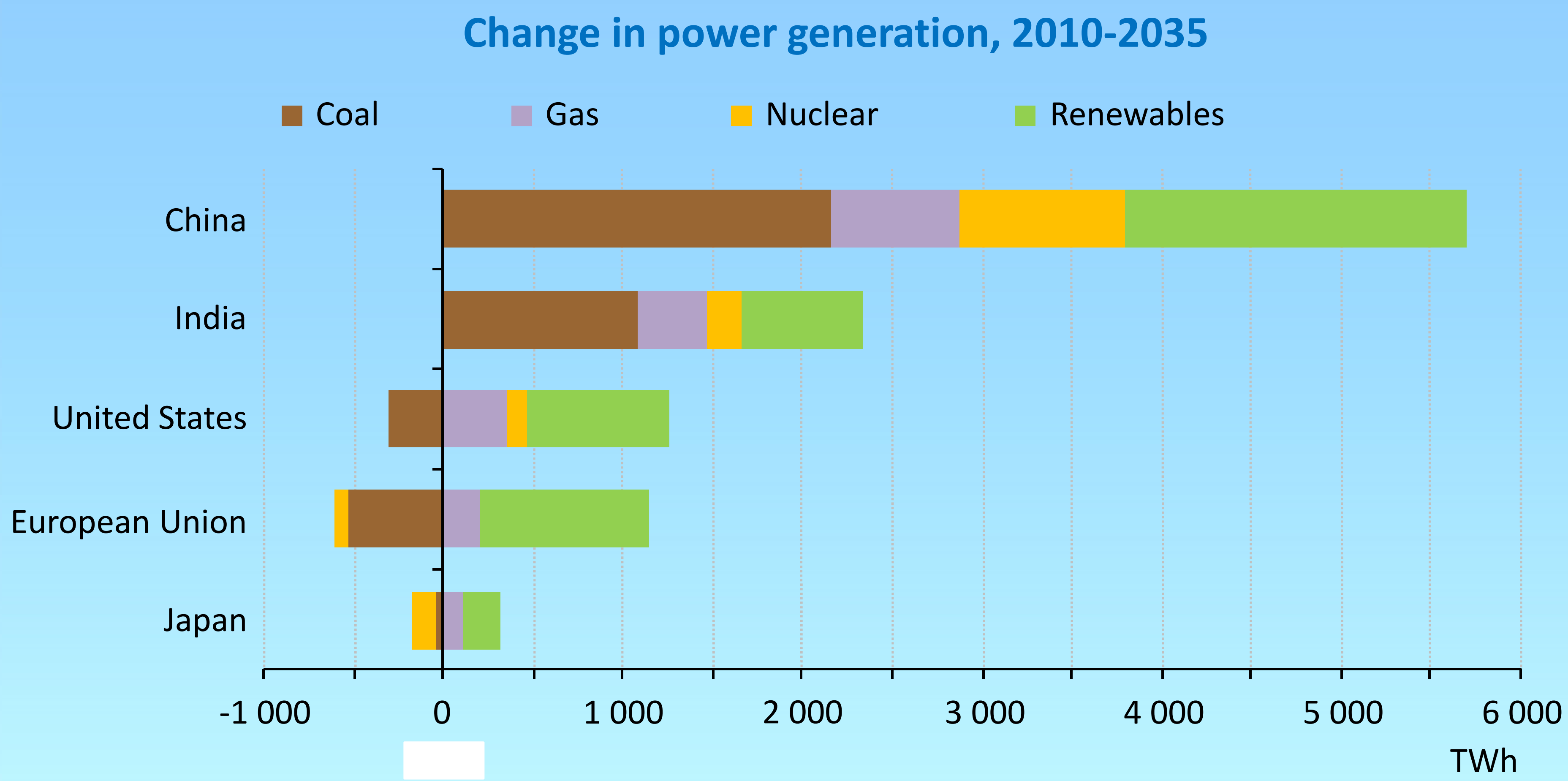


Fossil fuels account for 60% of the overall increase in demand, remaining the principal sources of energy worldwide

Comparative changes in coal, oil and gas prices (World Bank 2013)

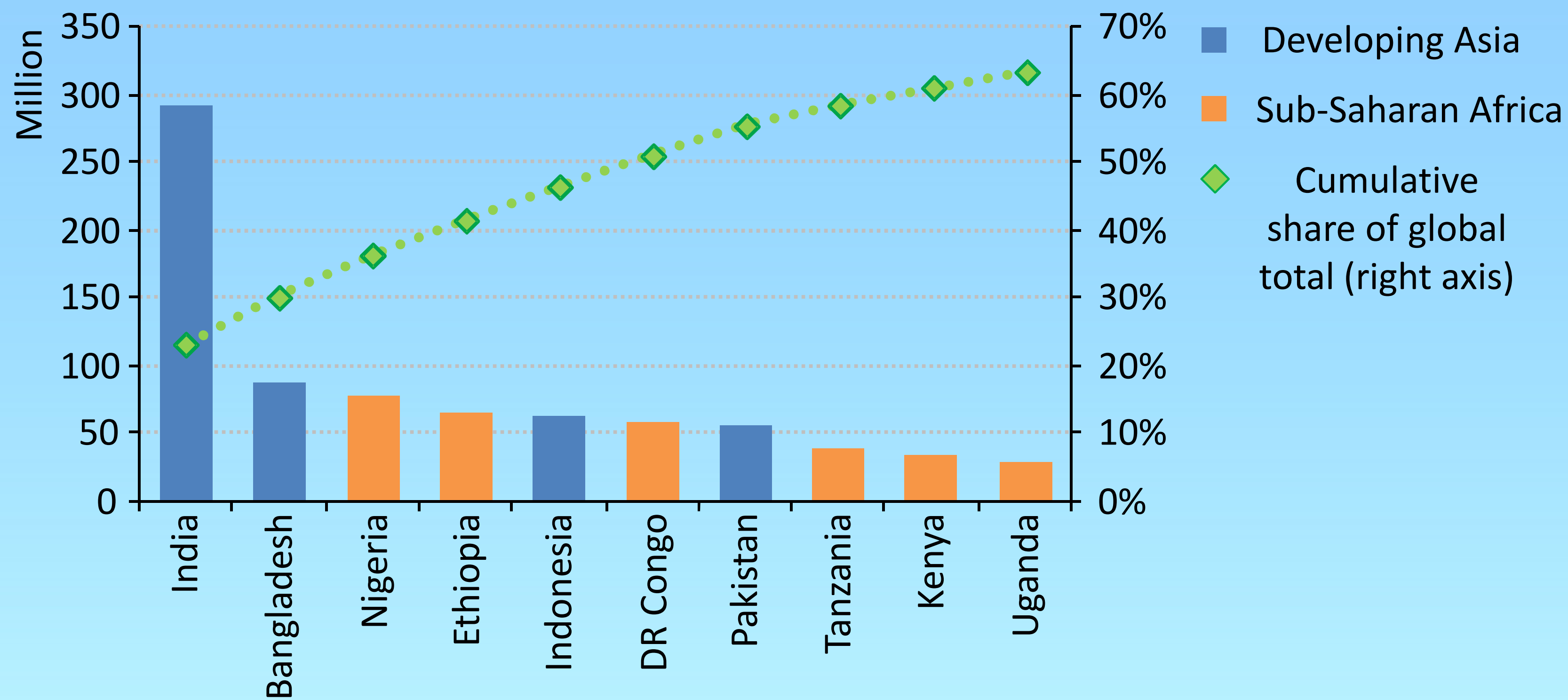


IEA WEO 2012
A power shift to emerging economies



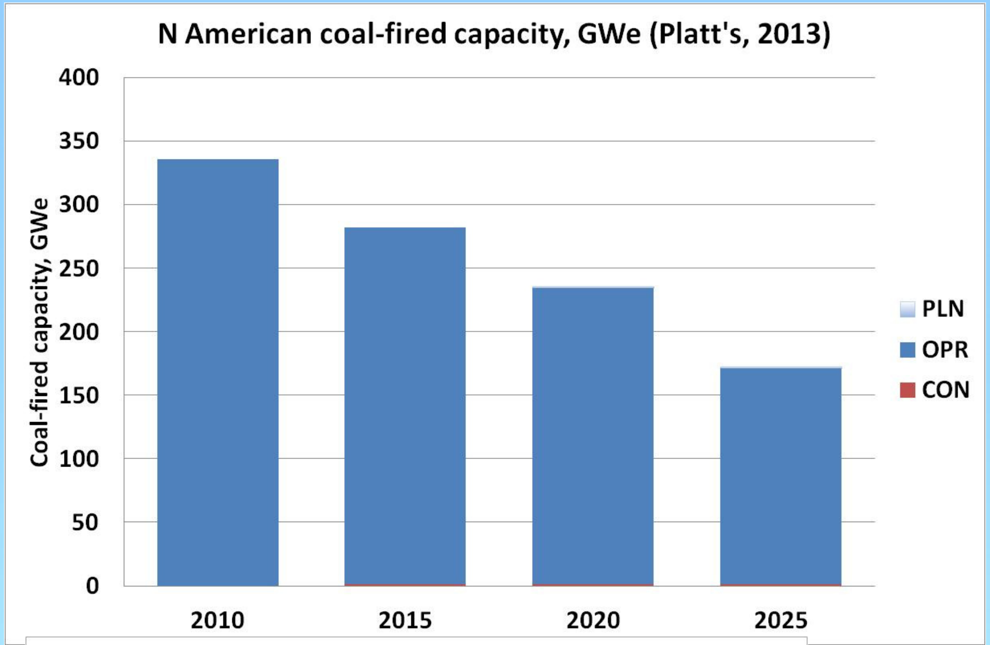
The need for electricity in emerging economies drives a 70% increase in worldwide demand, with China & India accounting for over half of the global growth

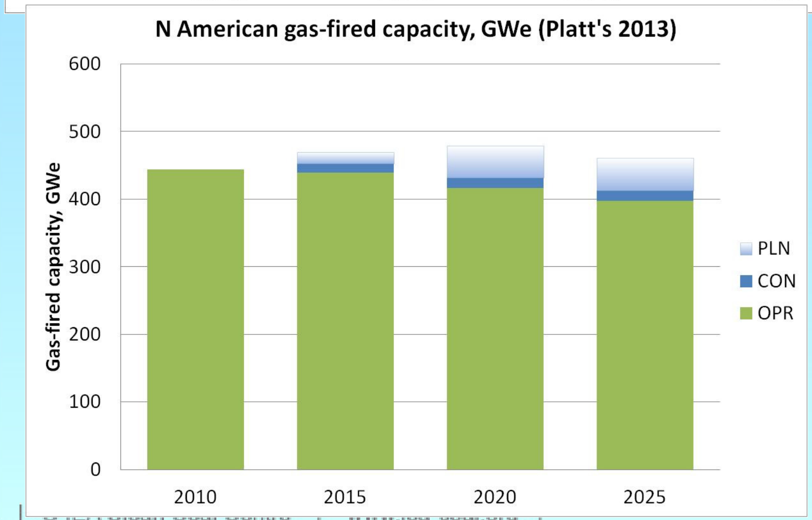
Countries with the largest population without access to electricity in 2010



Over 95% of those without electricity are in developing Asia or sub-Saharan Africa & nearly two-thirds are in just ten countries (IEA WEO 2012)

North America coal power



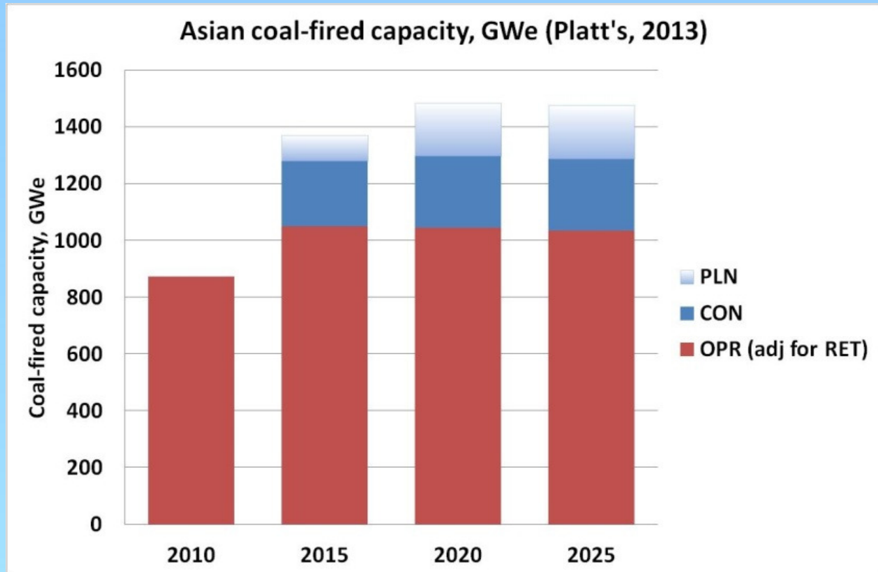


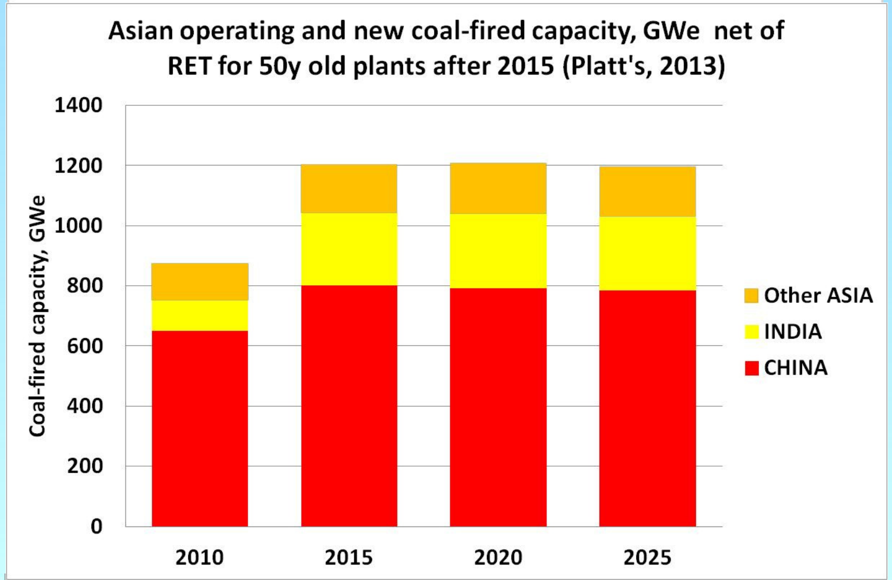
Projections assume massive conversion to gas power, driven by low cost shale gas.

Some expectation that the USA will not only export lowish priced coal that cannot be used at home but also shale gas that can undercut other international supplies.

Current reality appears far more complicated. Preferential use of coal or gas almost cyclic due to gas struggling to remain competitive without the export opportunities.

Coal power in Asia





Projection looks to be a significant underestimate, just based on likely capacity additions planned for China and India

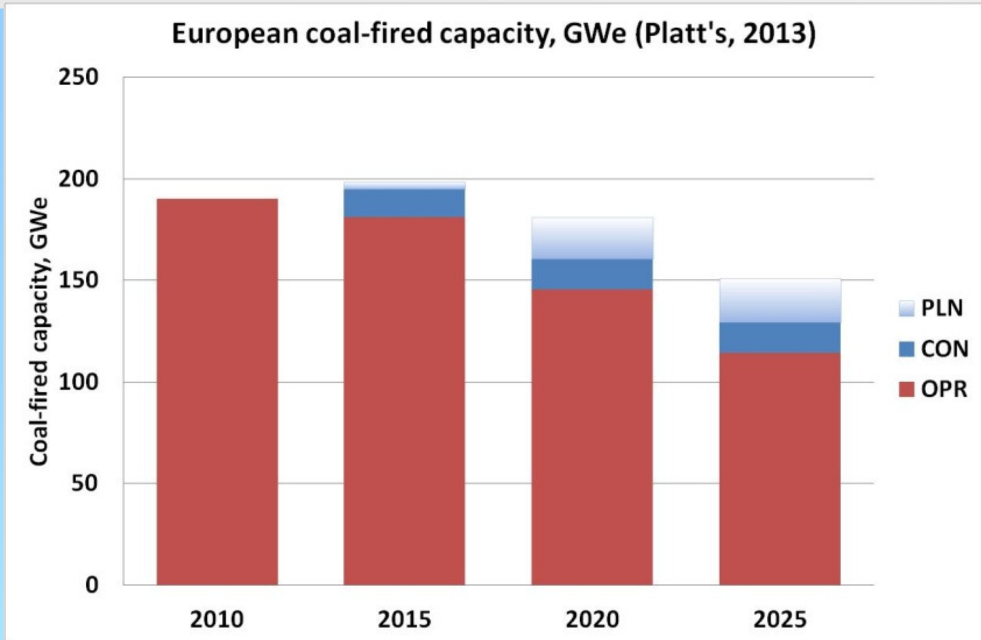
Coal power in China planned to grow in absolute terms but fall in relative terms in overall power sector energy mix.

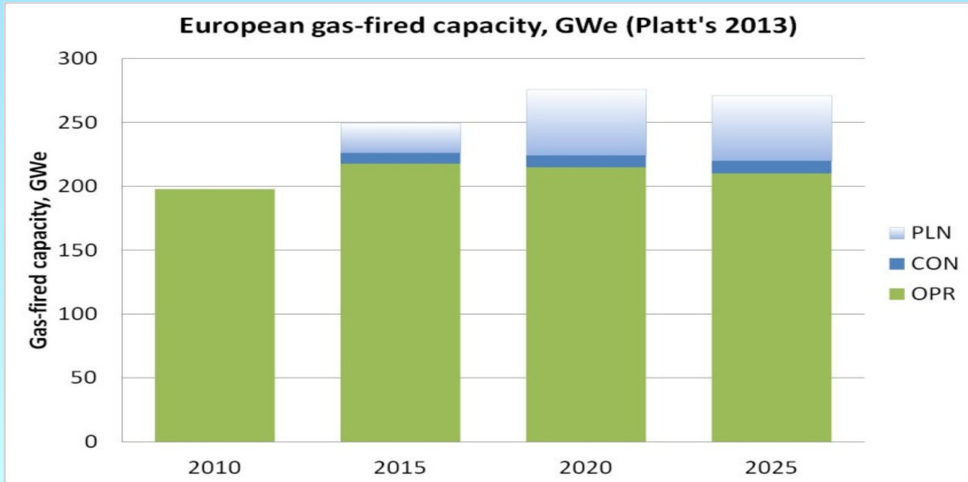
India's plans less convincing but the intention is to grow coal use significantly, including use of imports.

In both countries, coal use for non-power applications is expected to increase considerably.

Projections need to better factor in increase in coal use in SE Asia

Coal power in Europe





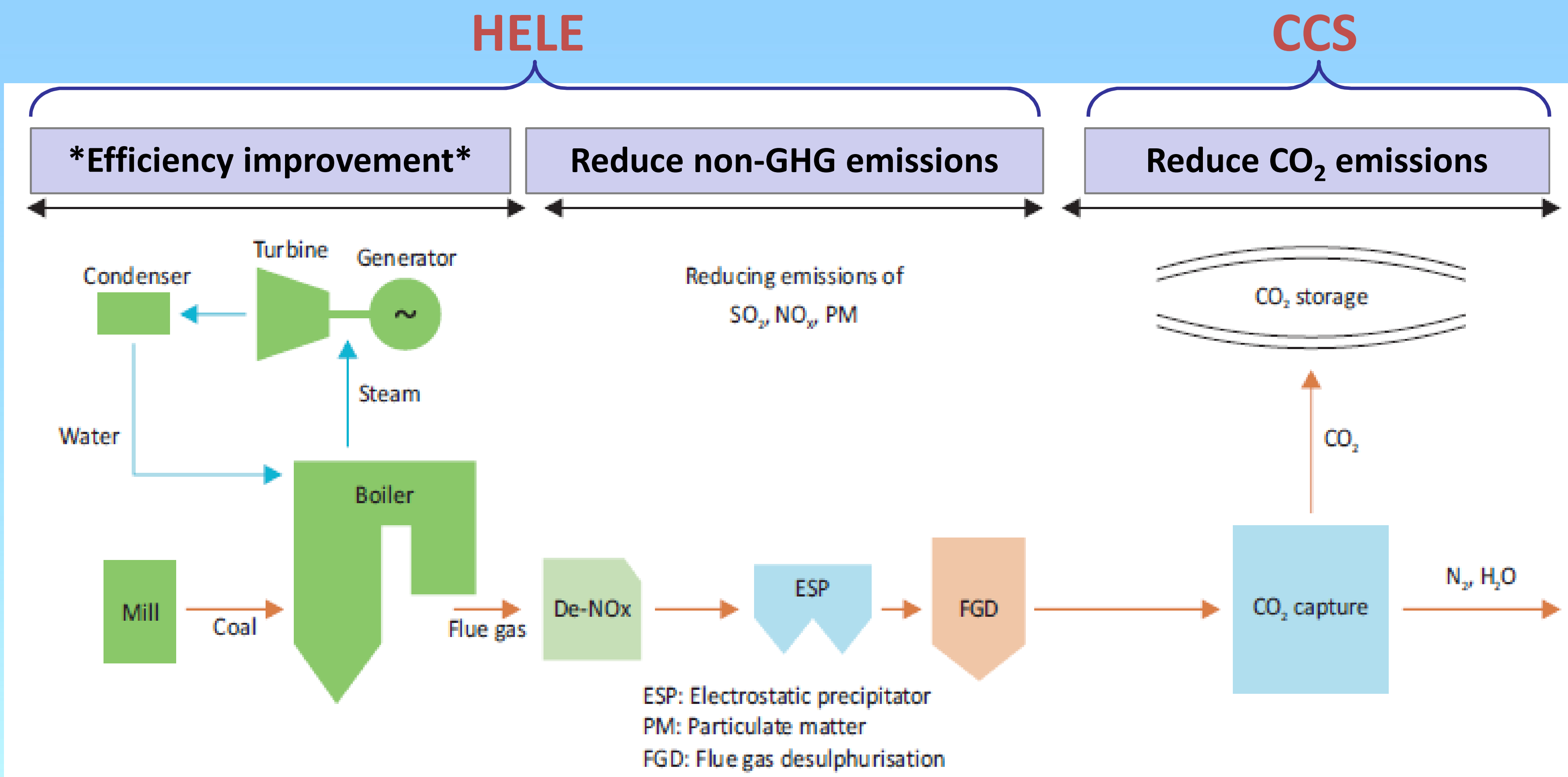
Within EU, low priced imports of USA coal are fuelling a surge in demand. New coal plants being built and planned in Holland, Germany and Poland. In many countries, natural gas use is squeezed between lower priced coal and renewables obligations.

In Eastern Europe and the Balkans, new coal plants are being built with large market prospects.

Turkey represents a major market for new coal power plant, both using imported hard coal and indigenous low grade coal.

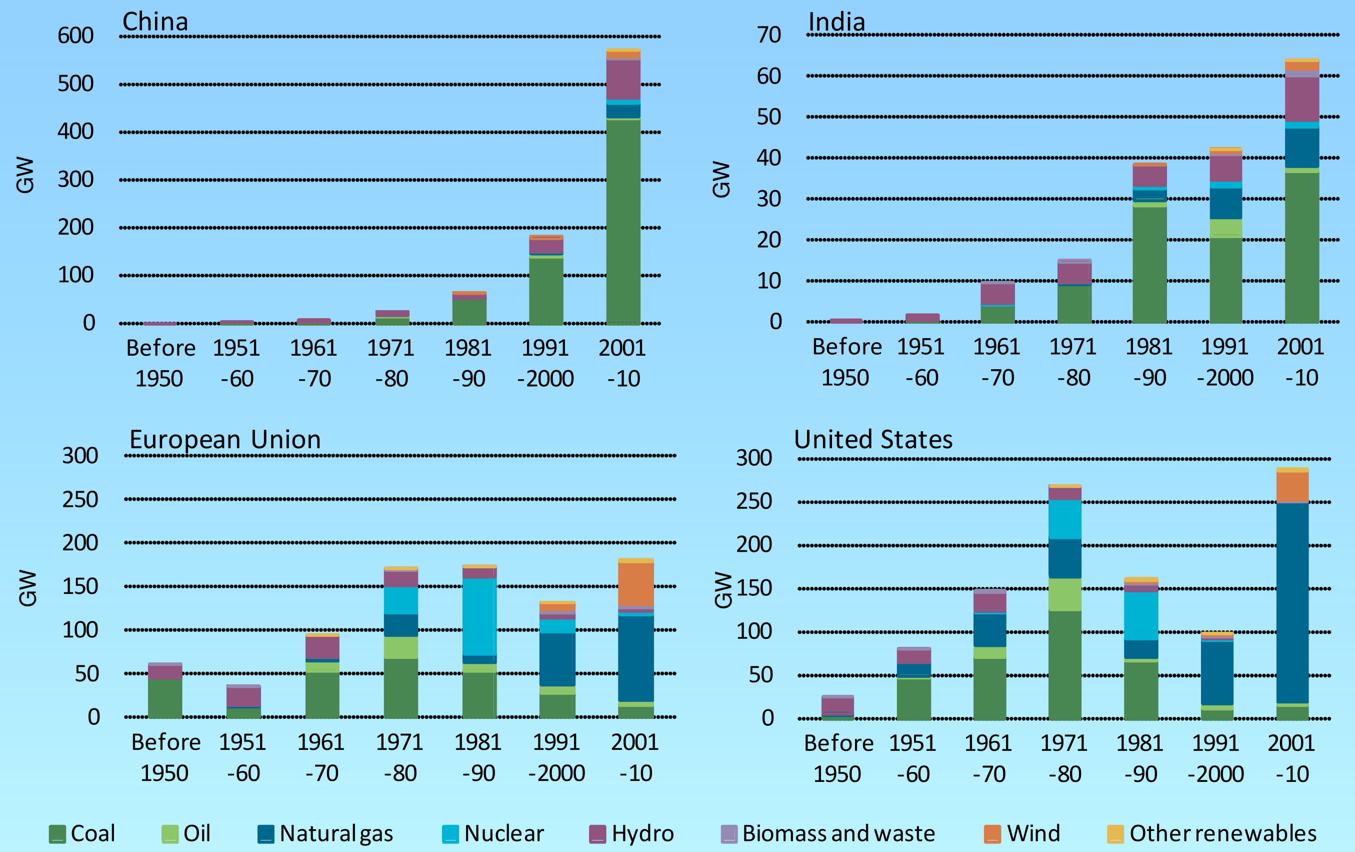
HELE coal-fired power generation

What are HELE technologies?



Efficiency improvement reduces specific fuel consumption and also reduces specific pollutant emissions.

Age distribution of existing power plants



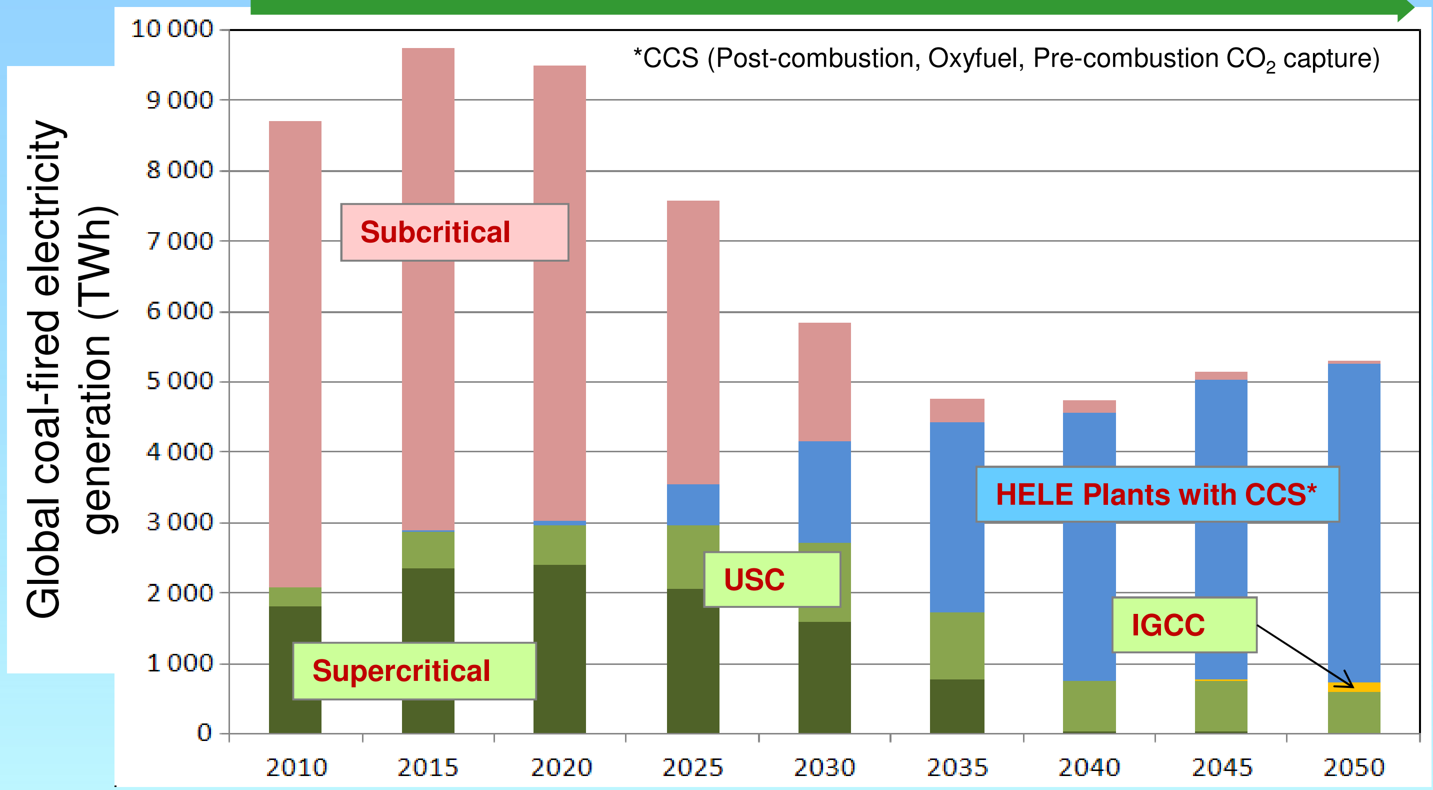
Ageing infrastructure is the challenge in many OECD countries.
Emerging economies have a growing demand for electricity.

Improve efficiency, then deploy CCS

Decrease generation from subcritical

Install CCS* on plants over supercritical

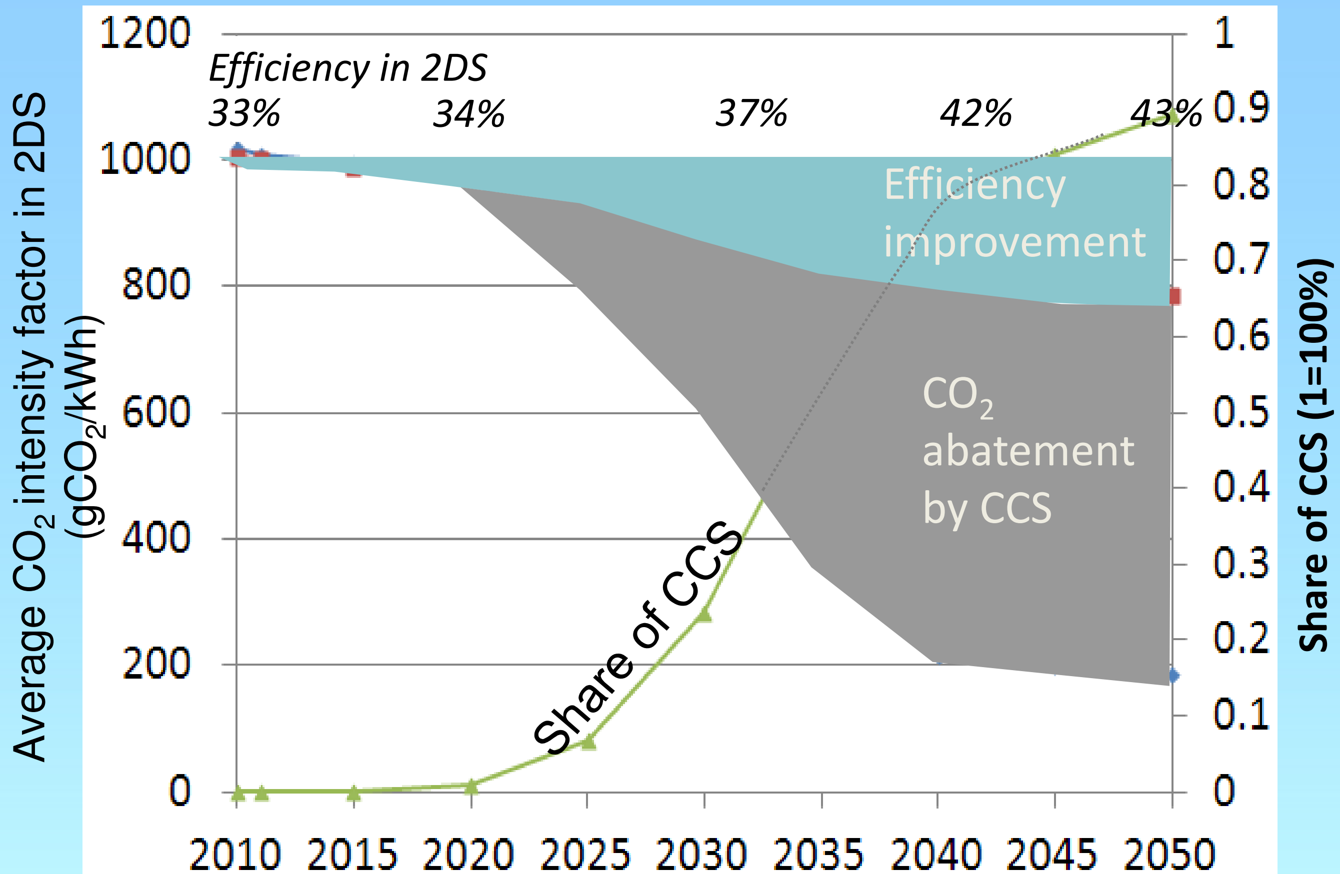
Increase generation from high-efficiency technology (SC or better)



* CCS fitted to SC (or better) units.

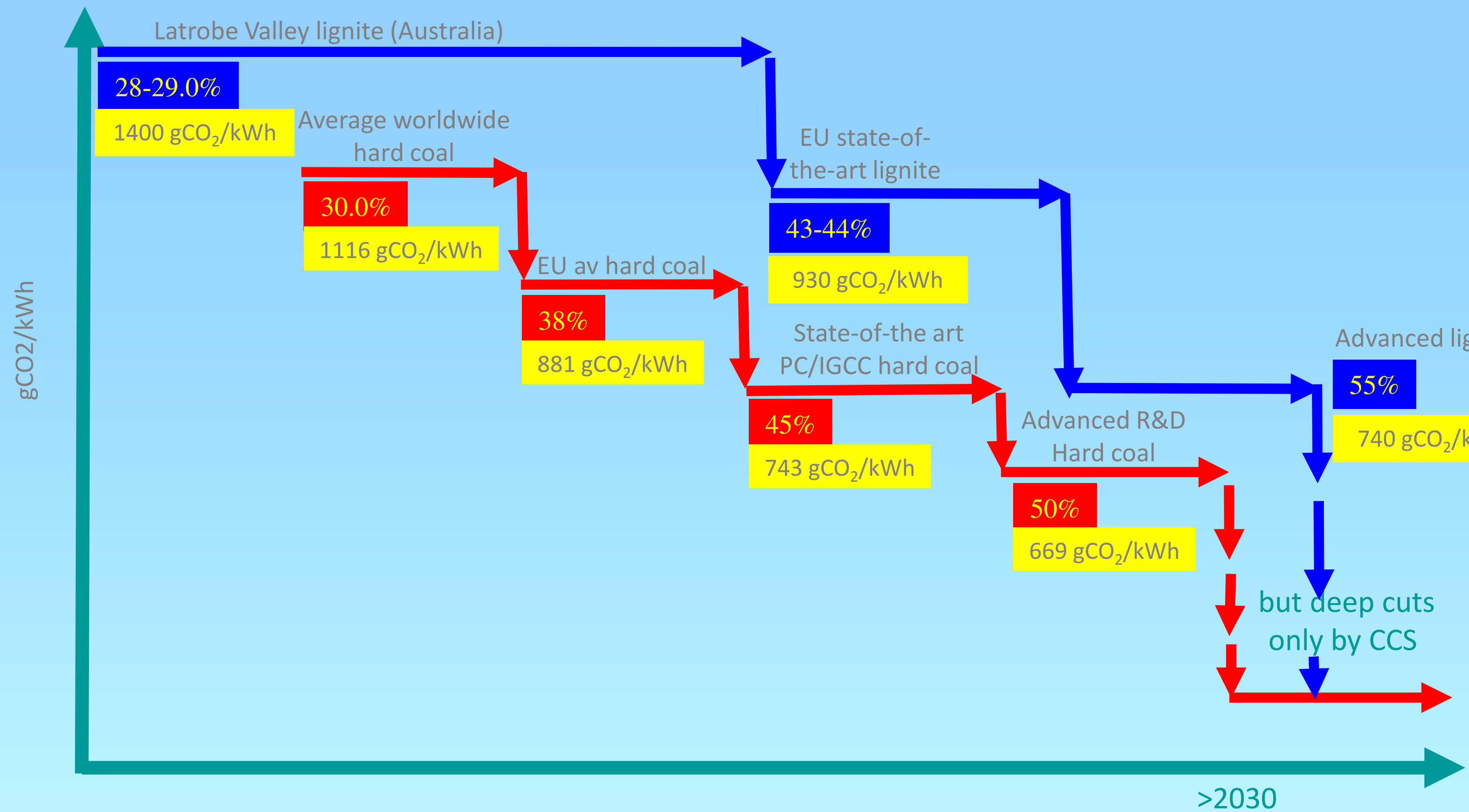
Three processes essential to achieve a low-carbon scenario

Impact of efficiency improvement on CO_2 abatement



Raising efficiency significantly reduces the CO_2/kWh emitted.

CO_2 emission reduction by key technologies

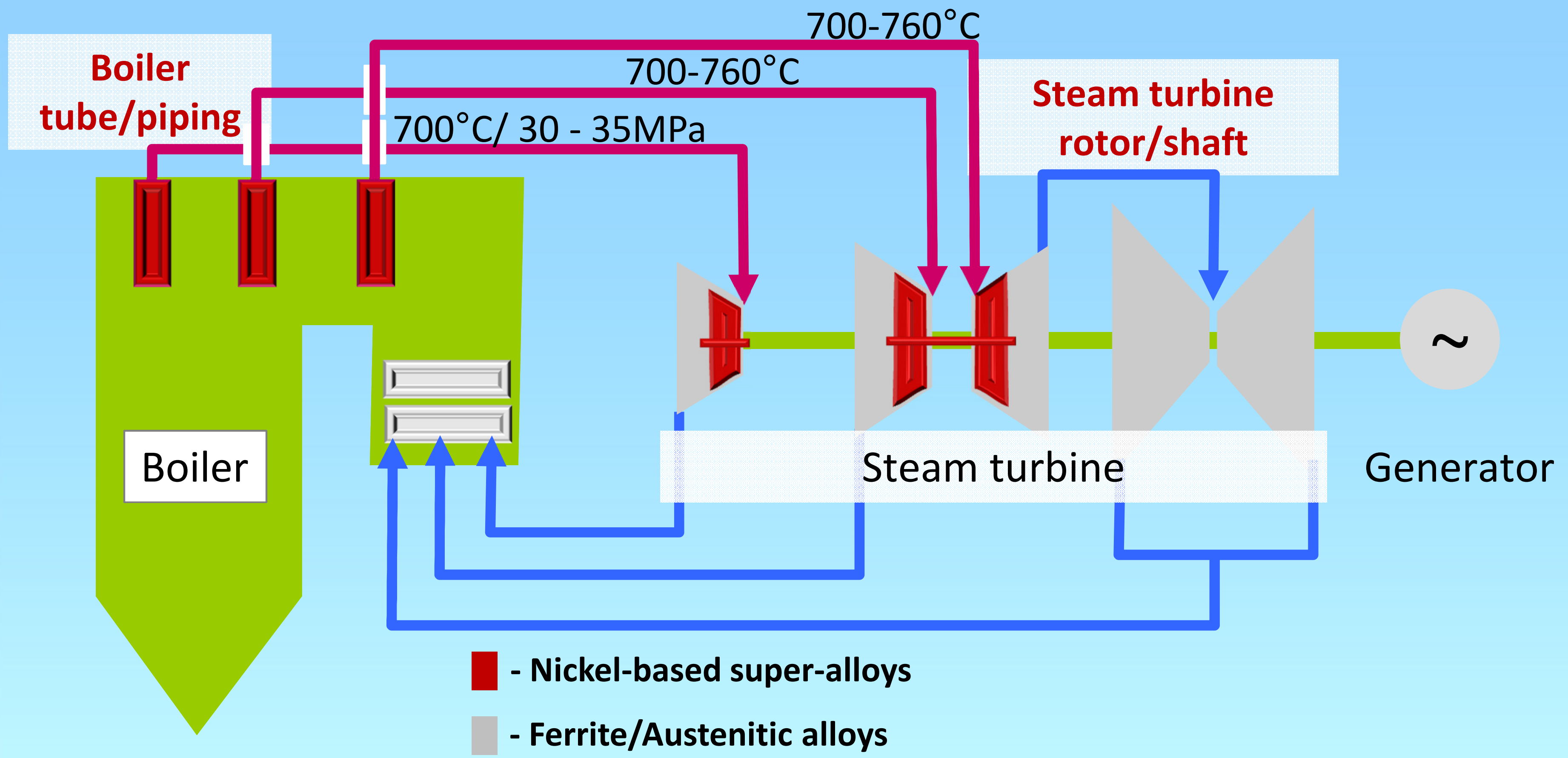


Data for hard coal-fired power plants from VGB 2007; data for lignite plants from C Henderson, IEA Clean Coal Centre; efficiencies are LHV,net

Energy Efficiency makes big change but deep cuts of CO_2 emission can be done only by Carbon Capture and Storage (CCS)

Huaneng Yuhuan 4x 1000MWe USC coal fired power plant

The challenge of advanced USC

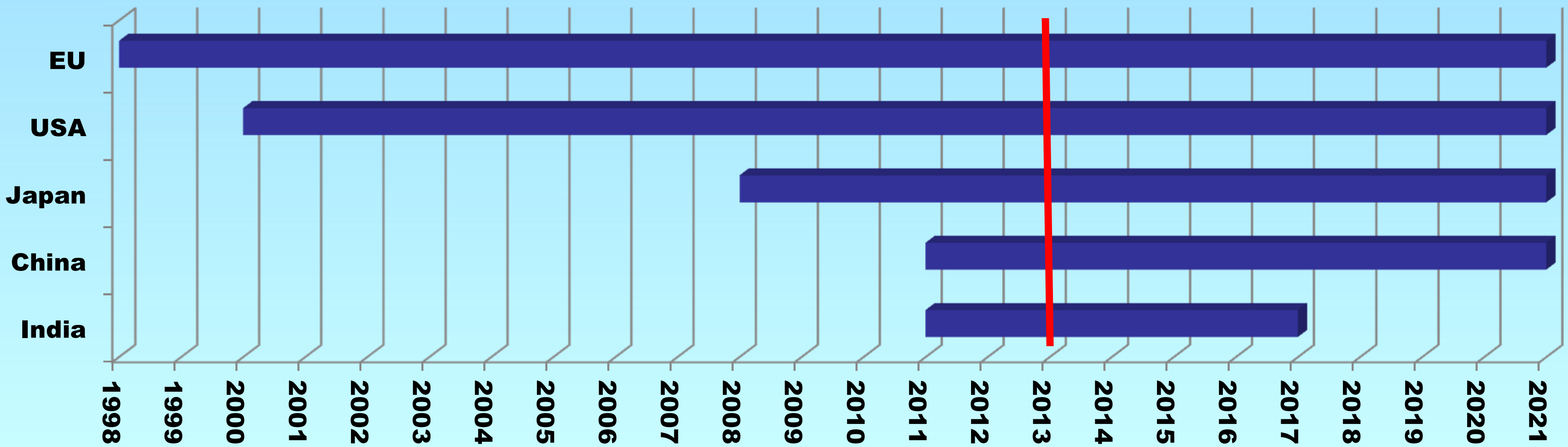


Nickel-based super-alloys will enable plant components to withstand temperatures of 700ºC and beyond.

Current state of A-USC technology

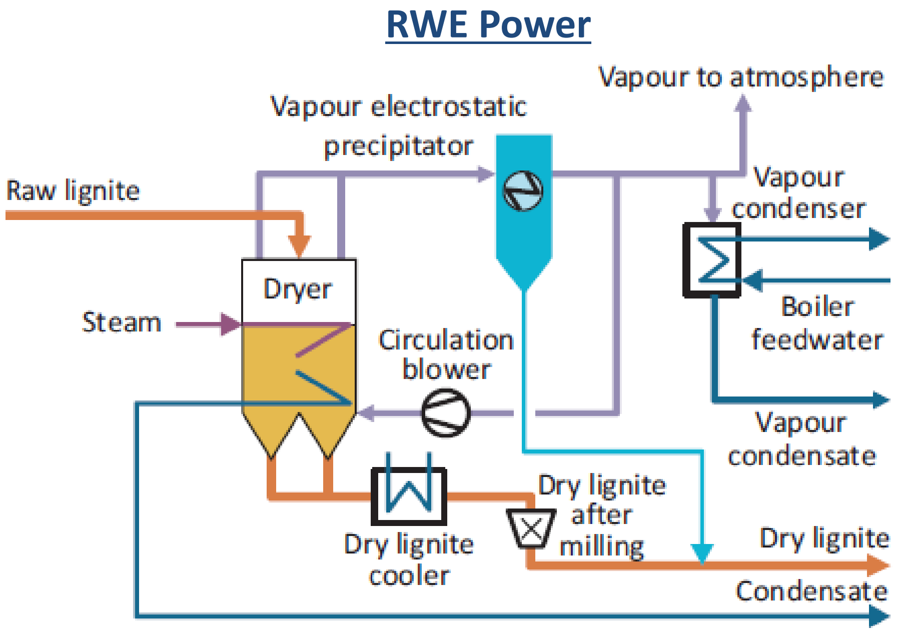
National programme	Steam temperature	Efficiency (LHV, net)	Programme start date	Demonstration plant operational by (size)	Also includes:
EU	700ºC	>50%	1998	2021 (500 MWe)	Coatings, biomass co-firing, cycling
USA	760ºC	45-47% (HHV, net)	2000	2021 (600 MWe)	Oxyfuel, coatings, high sulphur coal
Japan	700ºC	>50%	2008	2021 (600 MW)	Biomass co-firing
China	700ºC	46-50%	2011	2021 (660 MWe)	-
India	700ºC	>50%	2011	2017 (800 MWe)	-

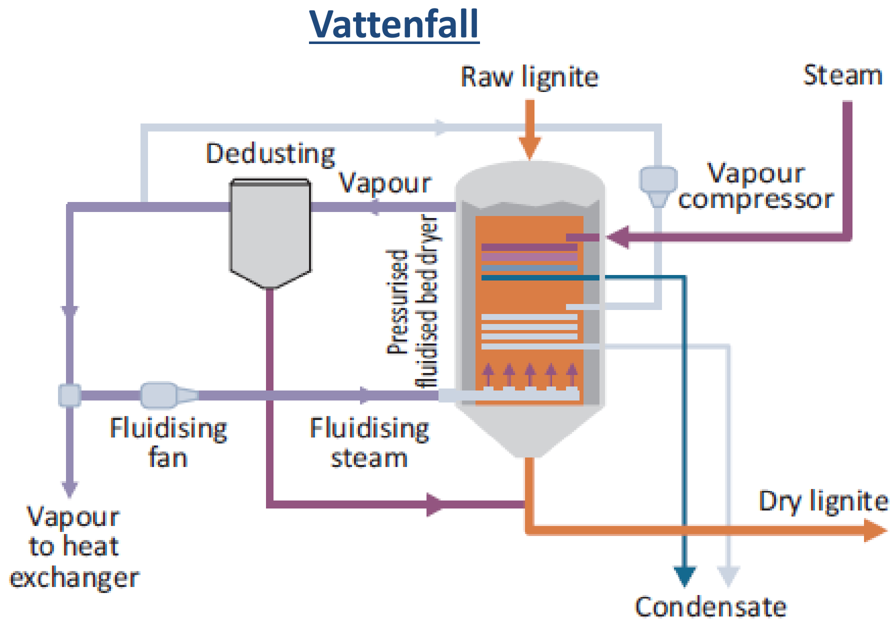
Timeline showing duration between programme start date and the planned date for an operational demonstration plant



Moisture reduction important for some coals

Advanced lignite pre-drying in pulverised coal combustion





The steam cycle is optimised for maximum efficiency.

Coal and Biomass

Energy production using combinations of coal and renewables

Biomass

- **forest residues**
  - thinning operations
  - logging
  - fire prevention
  - downstream processing
- **energy crops**

Wind power

Various ways to combine the use of coal, biomass and intermittent renewables have been proposed

Coal/biomass co-gasification

Advantages		
Coal	**Biomass**	**Co-gasification**
High energy content	May be low cost waste or residue	Large coal gasifiers – economies of scale - high efficiency, better economics
Widely available	Lower emissions	Allows biomass access to well-established processes
Large reserves	High availability in some countries	Smooths out seasonal biomass availability
Less prone to price fluctuations		Reduces impacts of variations in biomass properties
Usually costs less than biomass		Reduces coal plant emissions; possibly credits for the use of renewable fuel
Well proven in large-scale processes		Some biomass catalyses coal reactions; synergetic effects observed
Disadvantages		
Production-related impacts	Lower energy content	Storing, feeding, blending arrangements may be more complex
Conventional pollutant emissions	Variable properties	
CO_2 emissions	Harvesting, transport and pre-treatment costs	
	Seasonal availability	
	Tar, alkali issues	

Co-gasification projects

IGCC power plants			
Plant	**Capacity (MWe)**	**Gasifier**	**Biomass used**
Buggenum, Netherlands	284	Shell	Dried sewage sludge, chicken litter, sawdust
ELCOGAS, Spain	335	Krupps-Koppers PRENFLO	Olive wastes, almond shells, waste wood, vineyard wastes, MBM
Polk plant, USA	250	GE	Bahia grass, eucalyptus
Chemicals production			
Berrenrath, Germany	Methanol	HTW fluidised bed	MSW, dried sewage sludge, loaded cokes
Schwarze Pumpe, Germany	Methanol	Combination of BGL, FDV, GSP	Demolition wood, sewage sludge, plastics, MSW
Sasol, S. Africa	Various	Sasol-Lurgi	Bark, wood pulp/bark
ZAK + PKE, Poland	300 MWe + MeOH, chemicals	na	na

The Willem Alexander IGCC plant, The Netherlands

Dried sewage sludge

Chicken litter

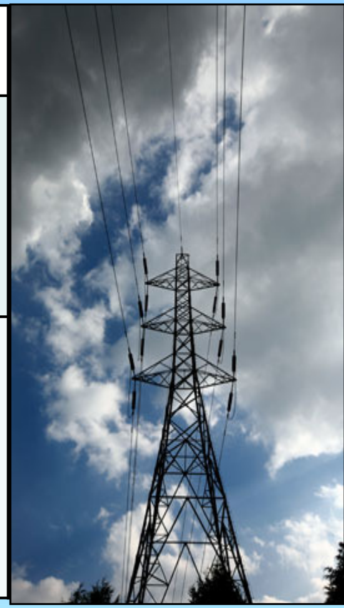
Sawdust

Combined gasification and renewable energy concepts

Organisation	Technologies proposed	Status
NREL, USA	Gasification/ co-gasification + electrolysis (wind)	Various studies under way. Concepts include: • combining wind power and biomass gasification • combining biomass gasification and electrolysis • combining coal and biomass co-gasification Several gasification-based hybrid systems being examined
NETL, USA	Coal gasification + electrolysis (wind)	Systems to produce SNG, electricity and biodiesel. 3000 t/d plant proposed. Unconverted coal from gasifier fed to oxy-combustor
CRL Energy, New Zealand	Coal/biomass co-gasification + electrolysis (wind)	Syngas could be used to produce low-carbon FT chemicals, synfuels Oxygen from electrolysis fed to gasifier Hydrogen - enrich product gas, stored, transport fuel, fuel cells
Leighty Foundn, USA	Coal/bio. co-gasification + electrolysis (wind)	Oxygen from electrolysis fed to gasifier
Univ. Lund, Sweden	Biomass (wood) gasifier + electrolysis (wind)	Oxygen from electrolysis fed to gasifier
Elsam/DONG Denmark	Biomass gasification + electrolysis (wind, solar)	Various co-generation concepts to produce power, heat, transport fuels examined. Hydrogen added to syngas. Oxygen for biomass gasification
Lausanne, Switzerland	Wood gasification + electrolysis	Several processes examined for SNG production
China	Various: Gasification + electrolysis (wind)	Oxygen from electrolysis fed to gasifier. Hydrogen fed to syngas. Mainly for SNG, methanol, ethylene glycol production

Summary

Gasification	• both coal and biomass gasified individually • many technology variants available for each
Coal/biomass co-gasfn.	• can provide advantages; overcome some problems • can be environmentally and economically beneficial • possibilities for producing a range of different products (SNG, chemicals, transport fuels) • a number of routes being pursued
Gasification + renewables combinations	• examined some of the more promising concepts being developed • particular emphasis on co-gasification coupled with wind-powered electrolysis (H_2, O_2) • many projects still at early stage in their development • some propose to incorporate CCS



<u>Co-gasification + renewables</u>

Some further advanced - some parts well established (co-gas) – other parts being trialled (commercial demo of H_2 production from wind, and advanced electrolysers).

If economics can be made to work, several concepts that combine coal, biomass and intermittent renewables look promising.

Drax Power in UK - 500MW Co-firing Facility

Drax is a pioneer in biomass direct injection technology

New 500MW co-firing facility is largest in the world

Capacity to co-fire >1.5m tonnes pellets per year

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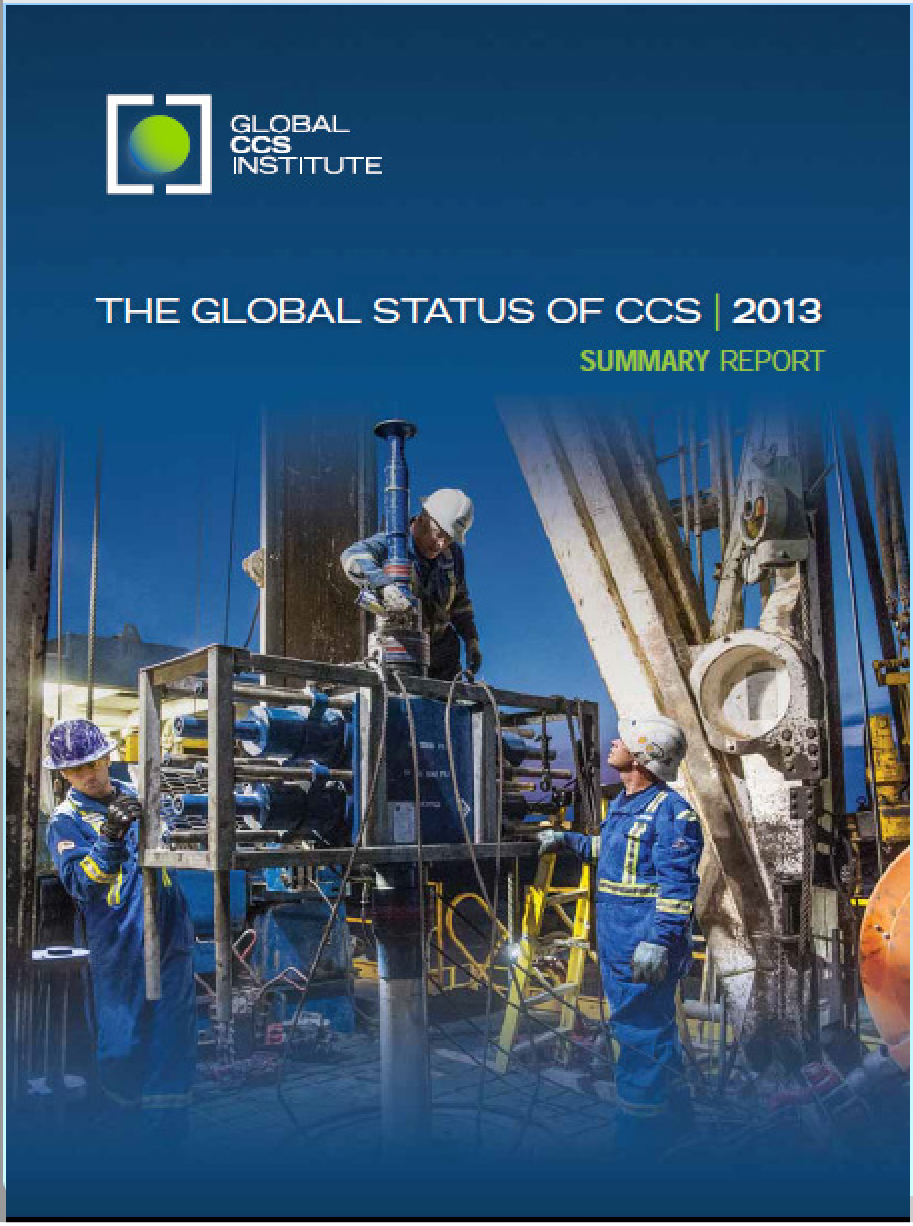


RECOMMENDATIONS FOR DECISION MAKERS

To effectively mitigate climate change and provide energy security, there is an urgent need to progress carbon capture and storage (CCS) demonstration projects around the world. Successful demonstration will build confidence by showing the technology in action and, through innovation combined with advances in capture technology, bring down costs.

It is vital that CCS is included in a portfolio of low–carbon technologies to tackle climate change at least cost.

We must therefore:

- implement sustained policy support that includes long-term commitments to climate change mitigation and strong market–based mechanisms that ensure CCS is not disadvantaged
- boost short-term support for the implementation of demonstration projects. This will require targeted financial support measures that enable first mover projects to progress faster through development planning into construction and provide necessary support during operations
- implement measures to deal with the remaining critical regulatory uncertainties, such as long-term liabilities. This will involve learning from the efforts of jurisdictions within Australia, Canada, Europe and the United States, where significant legal and regulatory issues have been, and continue to be, resolved
- continue strong funding support for CCS research and development activities and encourage collaborative approaches to knowledge sharing across the CCS community
- create a positive pathway for CCS demonstration by advancing plans for storage site selection
- encourage the efficient design and development of transportation infrastructure through shared hub opportunities to become 'trunk lines' for several carbon dioxide capture projects.

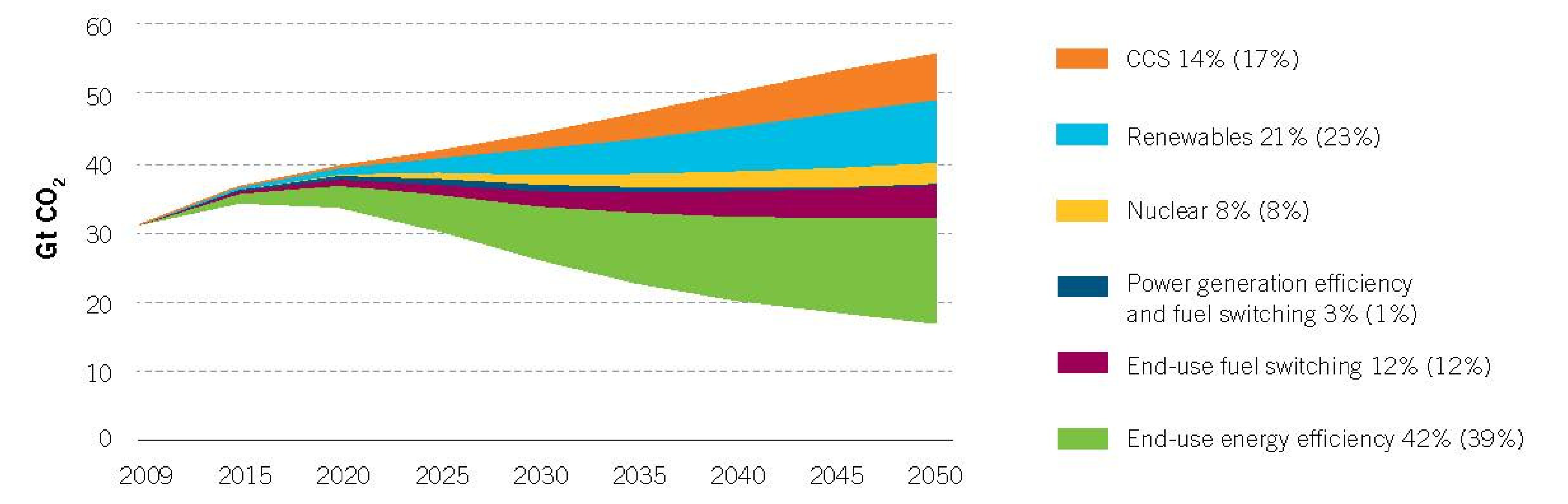
GCCSI – Report 2013
As reported in Power Engineering magazine

Number of global large-scale integrated CCS projects drops in 2013
10/11/2013

The number of global large-scale integrated carbon capture and storage projects (LSIPs) dropped from 75 to 65 in 2013, according to a report from the Global Carbon Capture and Storage Institute. The institute monitors the number of LSIPs as a method of tracking the progress of CCS developments and defines LSIPs as "projects considered to be at a sufficiently large scale to be representative of commercial-scale process streams." The report states 13 LSIPs have been removed from the institute's list since 2012, with five of those being canceled, seven put on hold and one downscaled. Three LSIPs were added to the list, however, reducing, bringing the total number to 65. According to the institute, four projects have commenced operation since 2012, making a total of 12 CCS projects in operation, and two projects have commenced construction since 2012, making a total of eight projects under construction. Of the 65 projects identified by the institute, the U.S. has the most with 20, with Europe second with 15 and China third with 12. The U.S. Environmental Protection Agency recently proposed a new rule that would limit CO2 emissions from new coal-fired units to 1,100 pounds of CO2 per megawatt-hour, which would require advanced emissions controls such as CCS.

http://www.power-eng.com/articles/2013/10/number-of-global-large-scale-integrated-ccs-projects-drops-in-2013.html

GCCSI – Summary Report 2013
Contribution of CCS to CO2 emissions reduction



Source: IEA, 2012.
Note: Percentages represent share of cumulative emissions reductions to 2050. Percentages in brackets represent share of emissions reductions in the year 2050.

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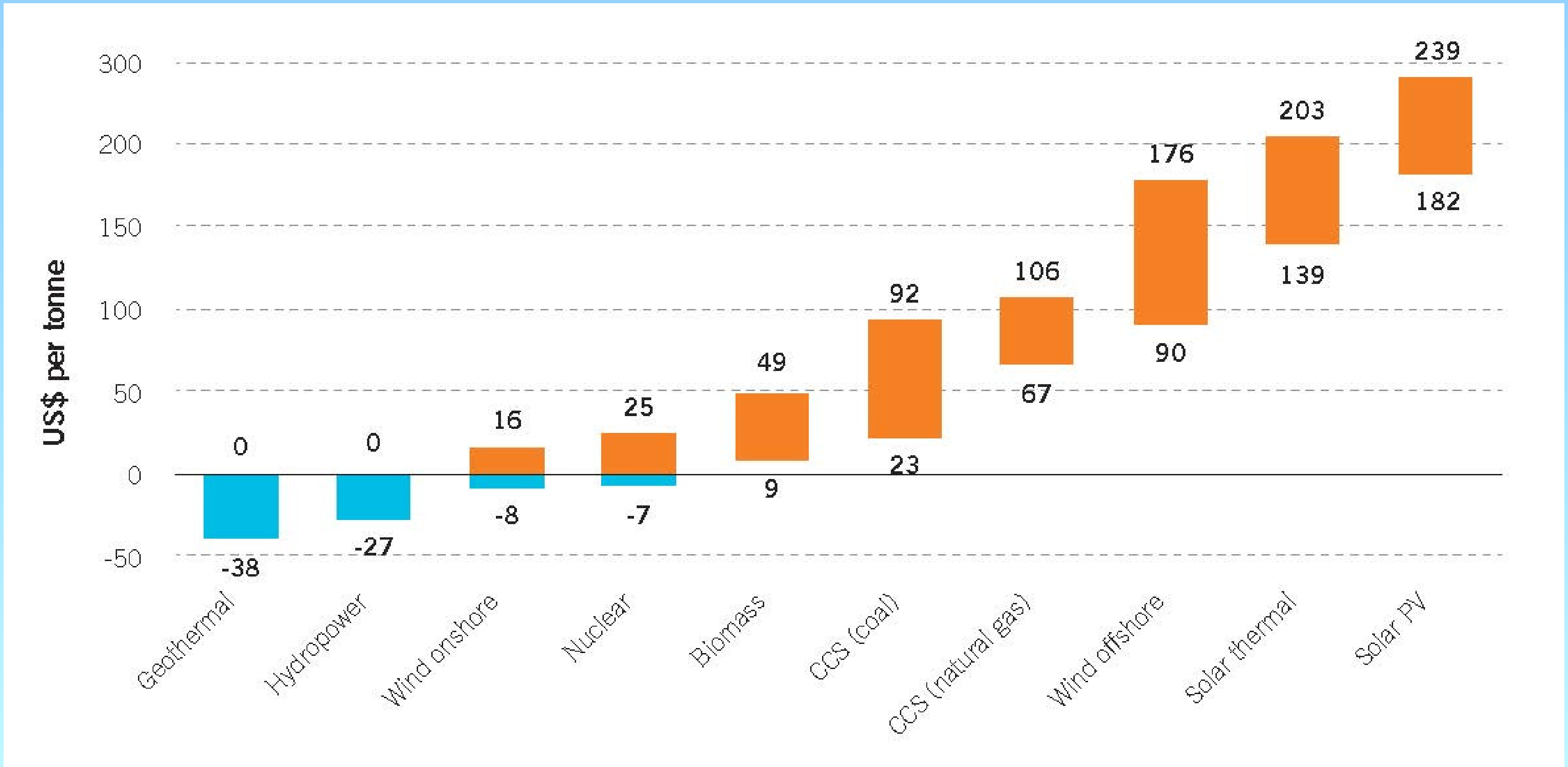
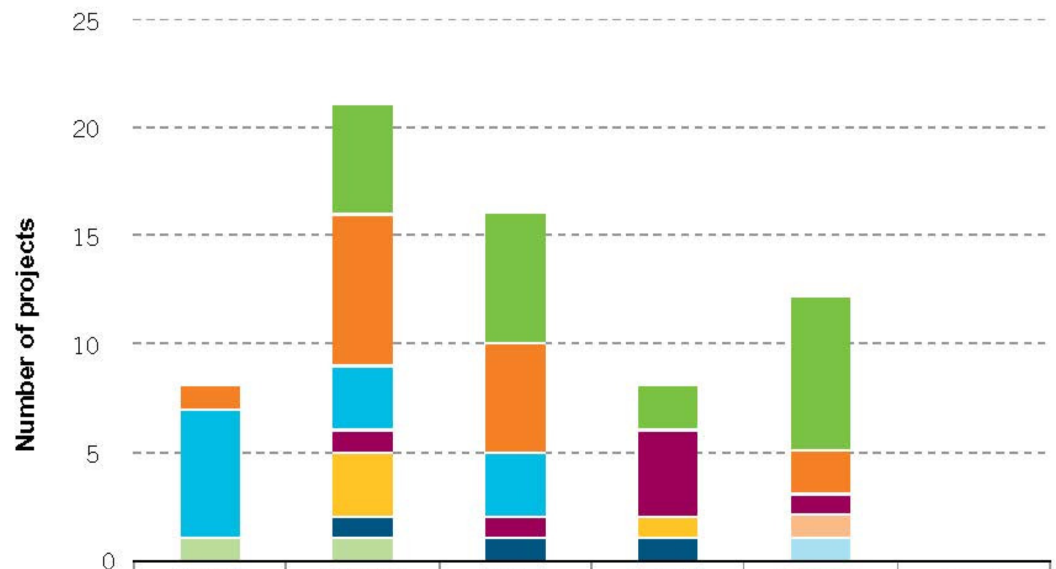
Costs of CO2 avoided in Power Sector



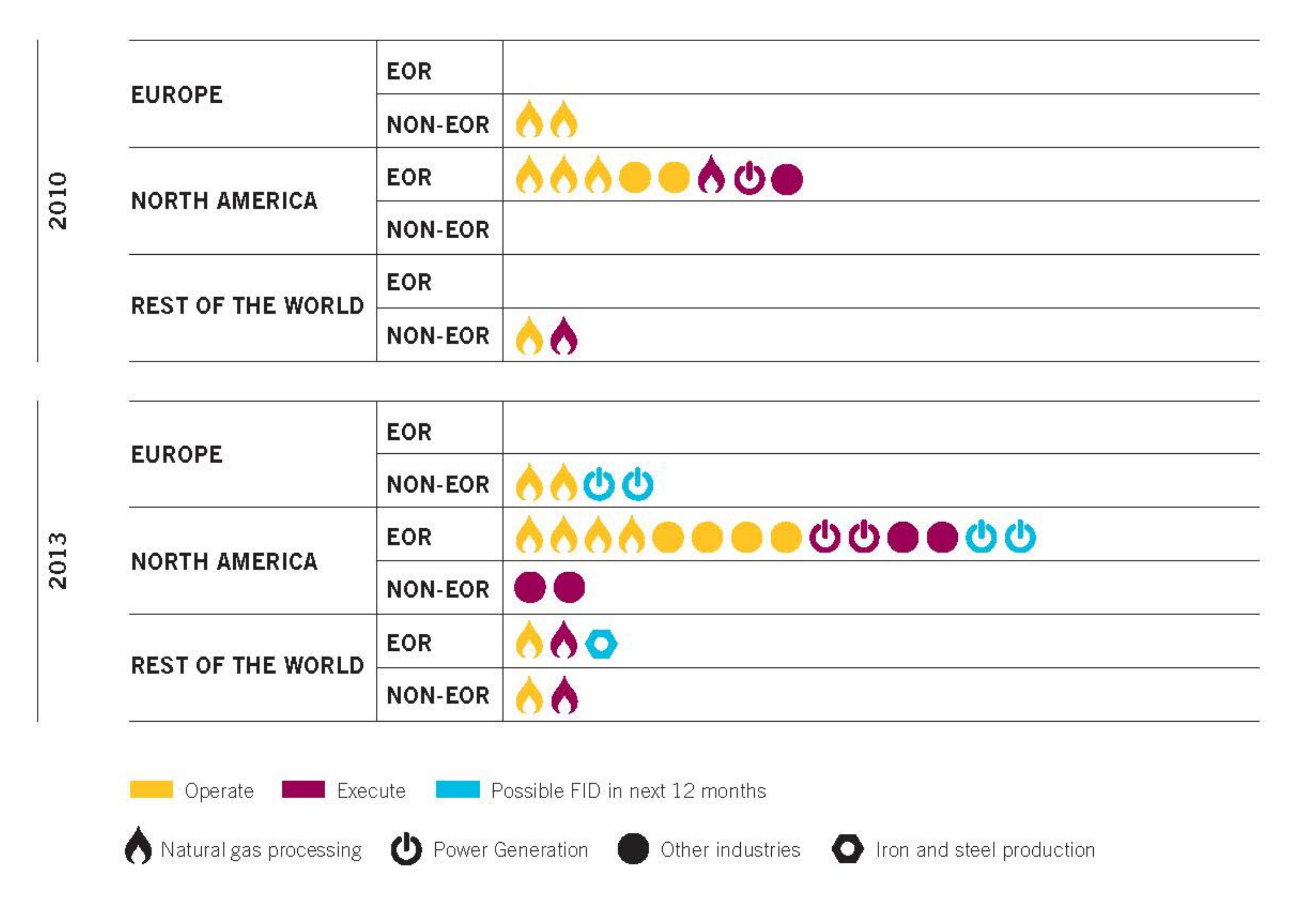
Note: For all technologies except gas–fired CCS plants, the amount of CO_2 avoided is relative to the emissions of a supercritical pulverised coal plant. For gas–fired CCS, the reference plant is an unabated combined cycle plant.

GCCSI – Summary Report 2013
LSIPs by Region and Status



	Identify	Evaluate	Define	Execute	Operate	**Total**
United States	0	5	6	2	7	**20**
Europe	1	7	5	0	2	**15**
China	6	3	3	0	0	**12**
Canada	0	1	1	4	1	**7**
Australia	0	3	0	1	0	**4**
Middle East	0	1	1	1	0	**3**
Other Asia	1	1	0	0	0	**2**
South America	0	0	0	0	1	**1**
Africa	0	0	0	0	1	**1**
Total	**8**	**21**	**16**	**8**	**12**	**65**

GCCSI – Summary Report 2013
LSIPS Progress since 2010



THE END

THANK YOU ALL FOR LISTENING

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