Overview of HELE coal combustion technologies

Dr Andrew Minchener OBE
General Manager
IEA Clean Coal Centre

IEA Clean Coal Centre members

Italy

Japan

Germany

Poland

CEC

S Africa

We are an international organisation, endorsed by the International Energy Agency. We provide independent, objective information on how to use coal more effectively, efficiently and cleanly, to minimise its environmental impact while providing cost effective energy

Australia

USA

Anglo American Thermal Coal

Suek

BANPU

Greenbank

Beijing Research Institute of Coal Chemistry

Electric Power Planning &Engineering Institute of China

GE Power

BHEL

DEWA

Doosan

What does the IEA Clean Coal Centre specifically do?

Four interlinked activities:

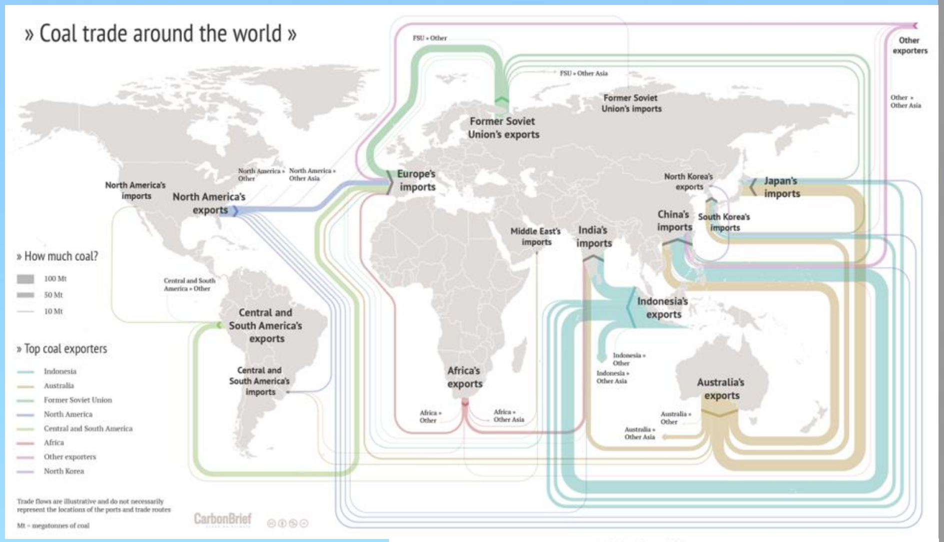
- **Provision of specialist support at request to individual members**
- **Coal based assessment studies,** covering both a wide range of technical issues and, increasingly, more policy and regulatory considerations plus global funding issues
- **Dissemination activities,** via website, the press and other media sources
- **Outreach activities,** increasingly in developing and industrialising countries and often in collaboration with like-minded organisations

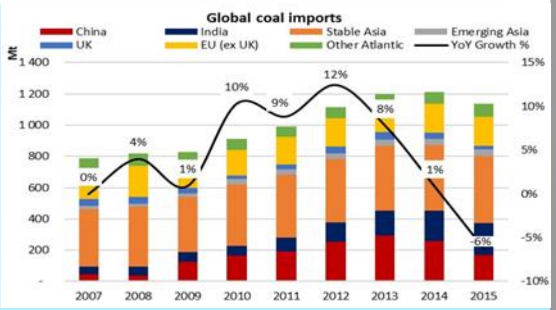
Scope of presentation

- Coal and global energy use
- HELE techology options and ongoing developments
- Air quality and emissions control
- Multi-pollutant control technology prospects
- Towards near zero emissions power plants by combining HELE with CCUS

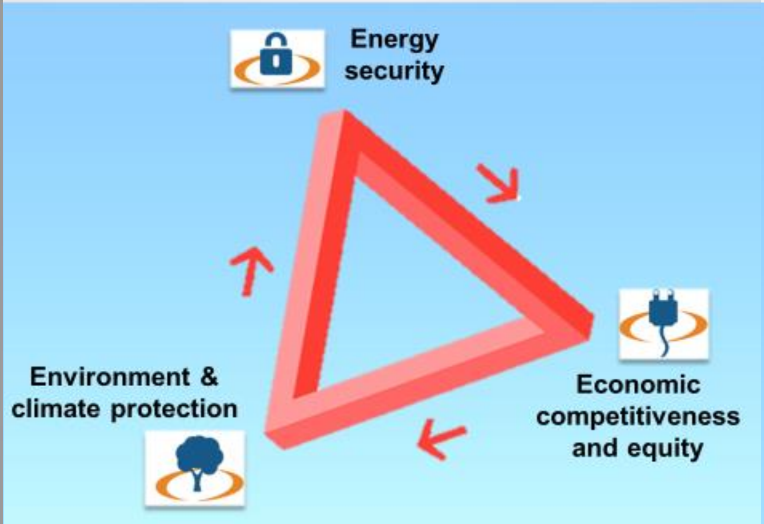
Importance of coal for global energy use

- Readily available worldwide
- Strong international trade
- Relatively low cost
- Lower price volatility
- Has lifted populations out of poverty
- Very suitable for grid based power generation





Coal meets key energy challenges worldwide and there is scope for overall performance improvement



Drivers for coal remain, as a means to lift populations out of poverty and to ensure robust reliable energy sources, for power, industry and chemicals/future fuels production, which will take forward industrialisation in developing countries.

- **Future for coal appears to be positive in Asia, while Africa, parts of the Middle East and South America show promise. Expectation is that coal will be used for decades to come in significant quantities with a focus on those non-OECD regions**

- **Coal has to be a part of the global energy mix but it needs to meet the three parts of the energy trilemma**

- **The aim should be to minimise the emissions of CO2 from coal, not cease to use coal itself, through improvements in efficiency and the subsequent introduction of CCUS**

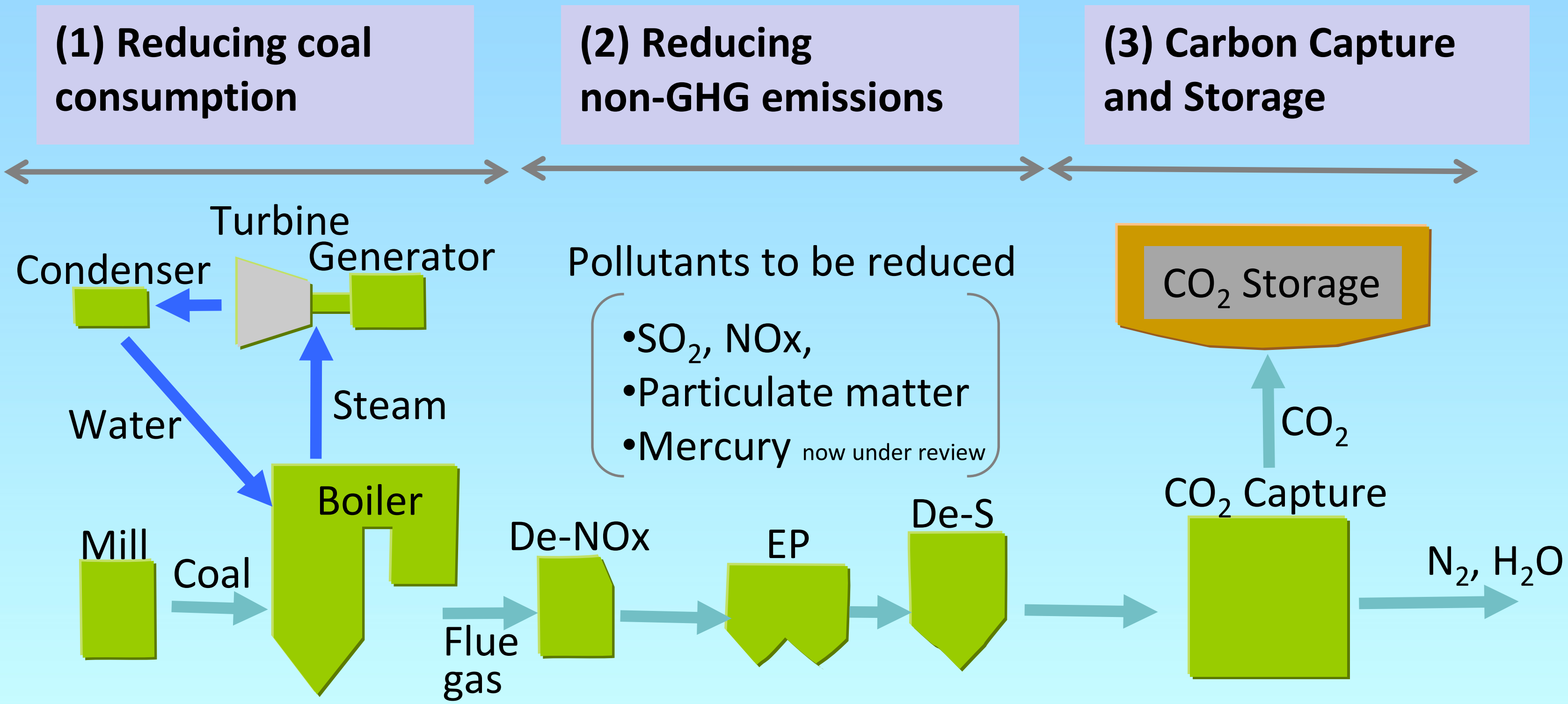
Strategic importance of HELE technologies

- Reality is that developing countries are going to use coal, as their driver is security of supply and economic competitiveness
- Many OECD countries will continue to use coal although they will likely have more balanced energy portfolios
- It is essential to support the use of more efficient coal-fired power, as it's the only realistic way to bring down CO2 emissions in the near term
- HELE clean coal technology is commercially available now and being deployed in Germany, Japan, Korea, USA but more especially in China and to a growing extent in India
- Development work is underway to establish advanced systems that will provide a step change improvement to over 50% cycle efficiency

HELE clean coal technologies are a key step towards near zero emissions from coal

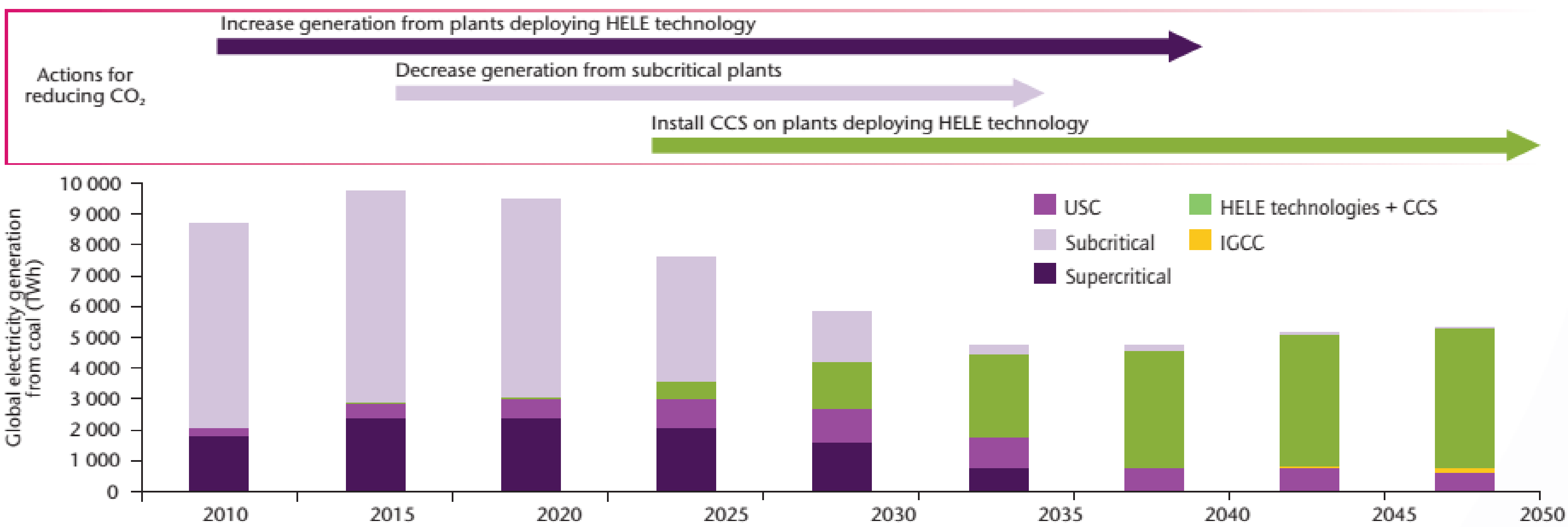
Focus on technologies to reduce both GHG and non-GHG (NOx, SO_2, PM) emissions.

Technologies for cleaner coal generation



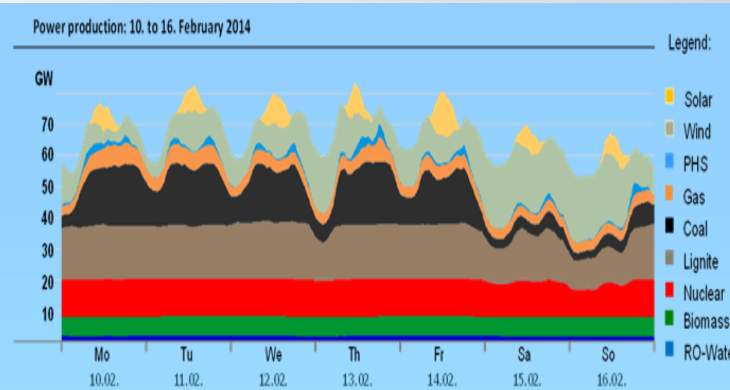
The IEA HELE roadmap

- Need for coal power is to increase the proportion of high efficiency coal plants built and deployed in place of inefficient, polluting units
- HELE technologies currently include USC, A-USC, and IGCC (in principle) , while average global coal efficiency is currently 35%
- ~40% world power generation is from coal: huge CO_2 savings possible by using HELE technologies
- Only 50% of coal plant built last year was SC – focus need to be to promote use of HELE plant in the developing world and raise average efficiency
- Adoption of CCS (once proven) will also be less demanding for HELE plant



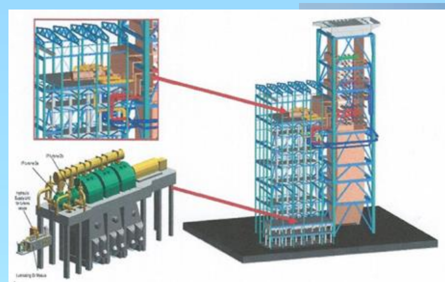
Ongoing improvements to ultrasupercritical pulverised coal fired power plants

Increased operational flexibility



Higher efficiency

(49-53% in the near to medium term)



Emissions (mg/m³)

Dust:	0.7
SO_2:	15.1
NOx:	17.2

Lower conventional emissions

Application of CCUS

(when policy framework is established)

Towards ≥50% cycle efficiency with advanced 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)	-

Metals used in boiler and turbine hot spots:

- **Steels well proven in USC at 600ºC**
- **Nickel based alloys proving capable in A-USC at 700ºC**

Efficiency, coal consumption and CO_2 emissions for various advanced coal power technologies in China (WWF European Policy Office 2016)

Technology	Net efficiency	House power rate %	Net coal consumption g/(kW·h)	CO_2 emissions (gross energy output) g/(kW·h)
Sub-critical	≤38.00%	4.5-5.5	323.25	798.59-807.32
Supercritical	≤42.00%	4-5	292.46	726.48-734.38
600℃ class USC	≤45.00%	3.5-4.5	272.97	681.73-689.10
700℃ class USC	45.00-50.00%	3	273.97-245.67	623.51-692.79
Pingshan1350MW 600℃ class USC（WGQ3's new design）	49.80%	3.5	246.66	622.69
WGQ3's700℃ USC	53.00%	3	231.76	588.21

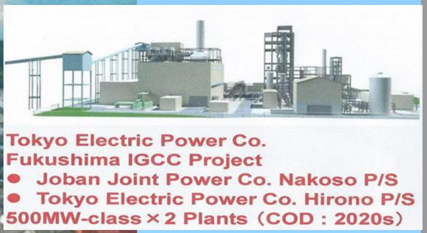
Note：1. Net coal consumption is based on standard coal with LHV of 7000 kcal/kg or 29308 kJ/kg

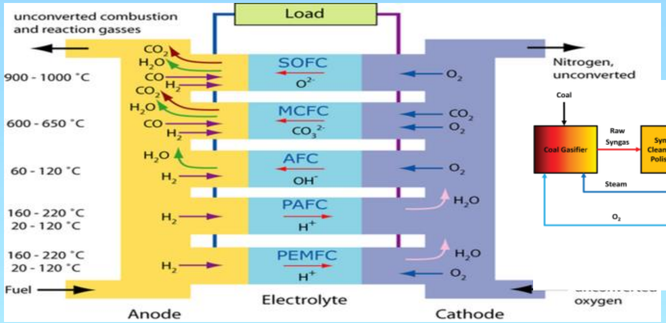
2. All the data are based on design conditions

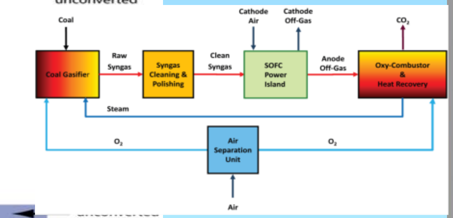
3. CO2 emissions are based on the gross energy output of the coal fired unit

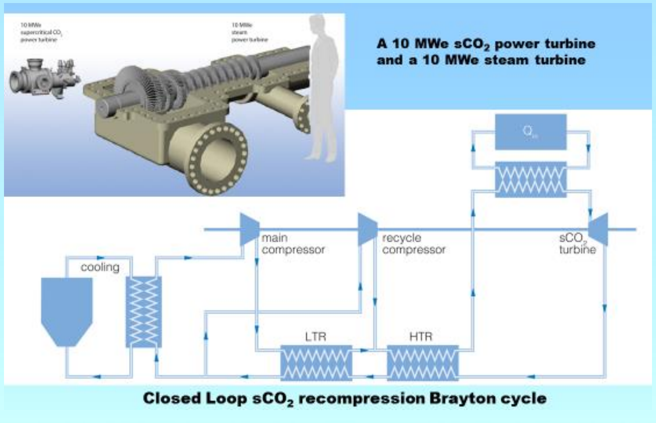
Where else do we go from here?

- **IGCC offers potential for high efficiency with very low emissions**
- **Fuel cell (FC) is an emerging technology that can potentially be applied to towards-zero emission, high-efficiency coal power plants**
- **Supercritical CO2 alternatives to steam Rankine cycles offer a transformational technology with very much higher efficiency and potentially lower costs**





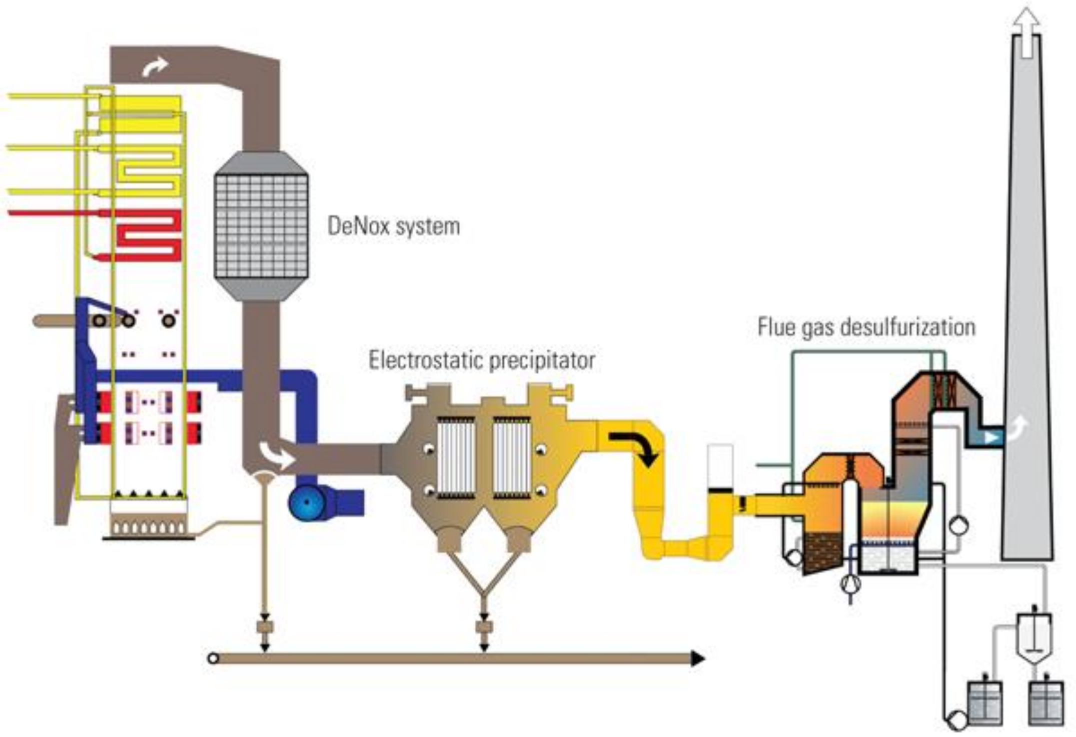




Air quality and emissions control

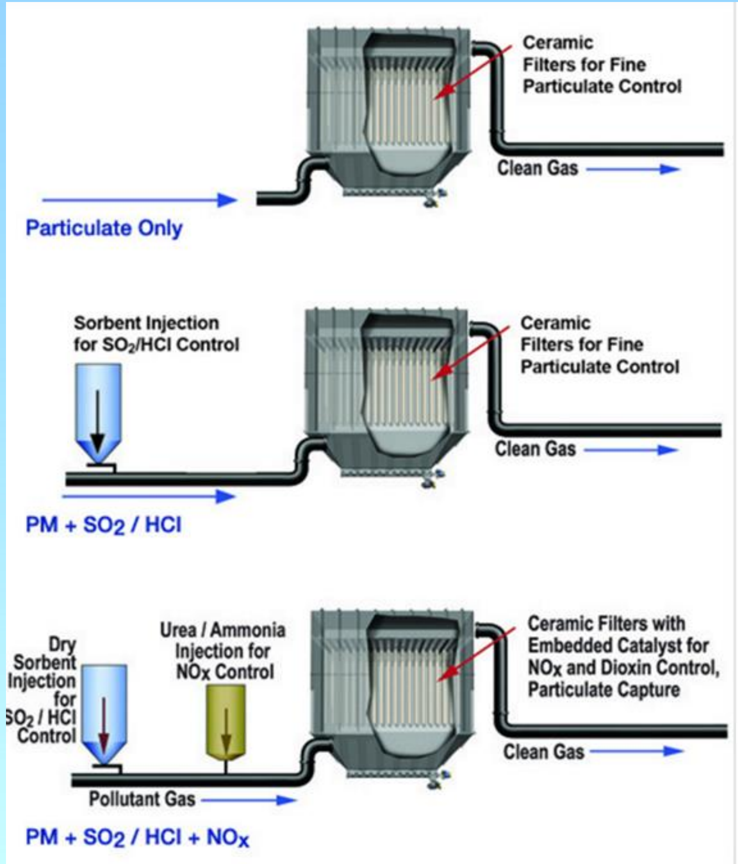
HELE coal power systems have state of the art emissions control devices to remove particulates, NOx and SO2

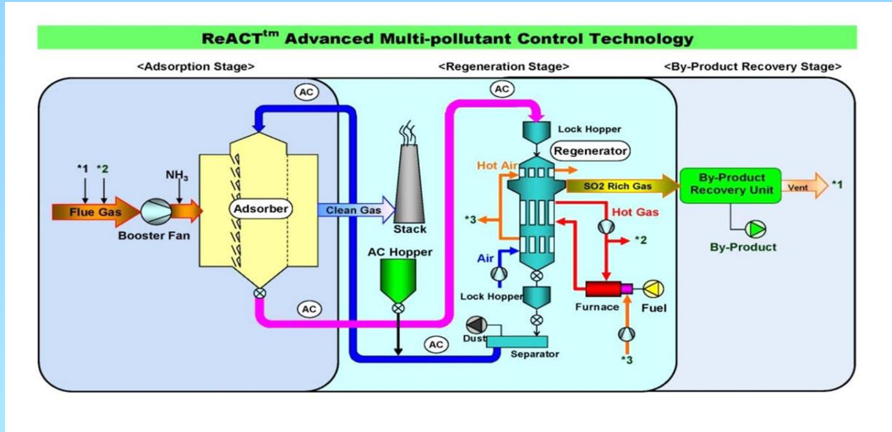
Emissions (mg/m^3)	
Dust:	0.7
SO_2:	15.1
NOx:	17.2

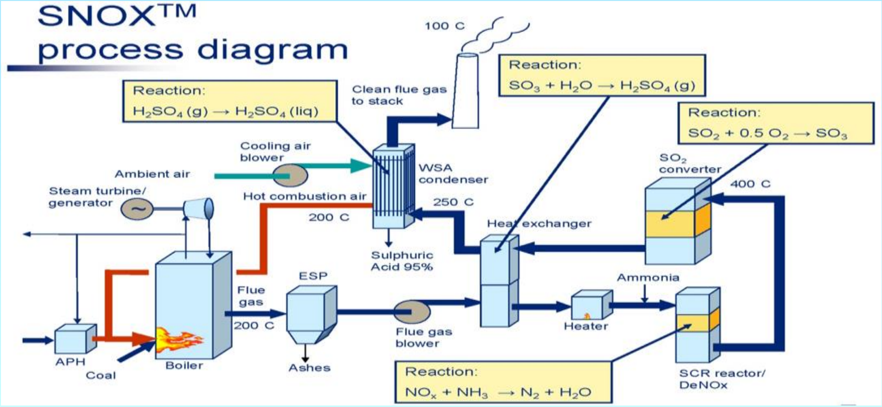


Multi-pollutant control technologies

- **Offers the prospect of removing several key pollutants in one stage, but costs and performance implications still need optimisation**

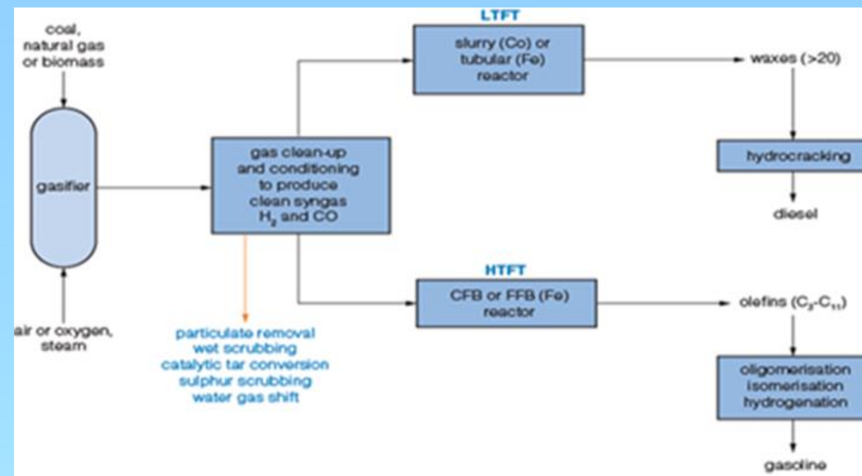


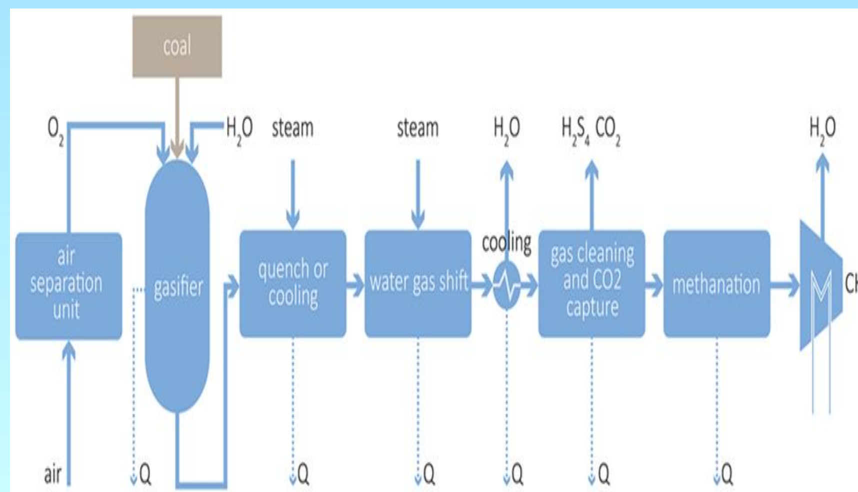




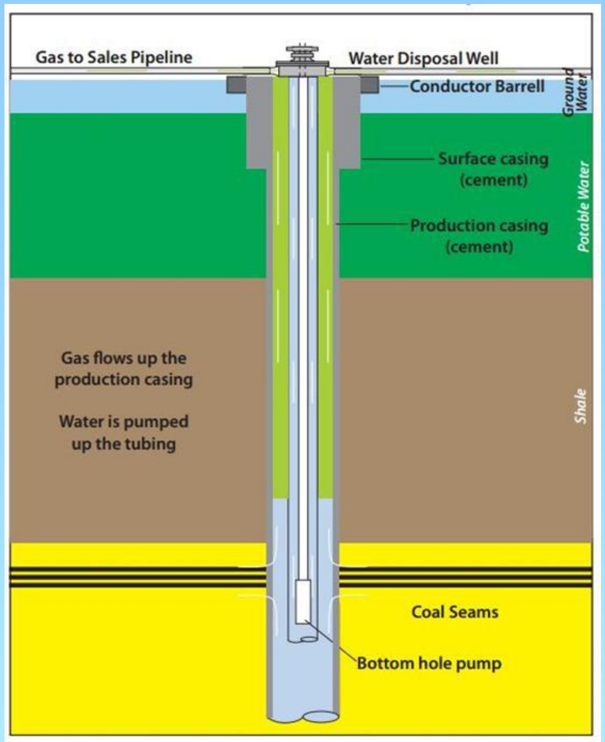
Future fuels from coal

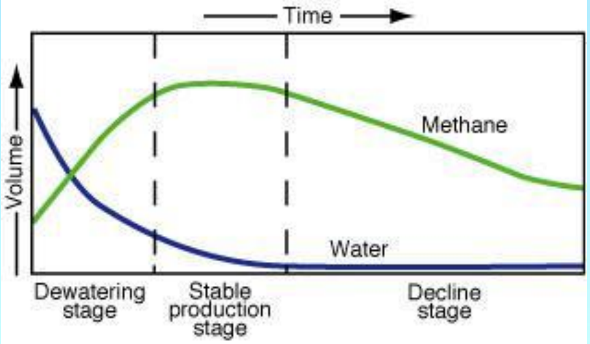
Coal can be upgraded to provide a range of chemical products including liquid and gaseous fuels





Extraction of coal bed and coal mine methane



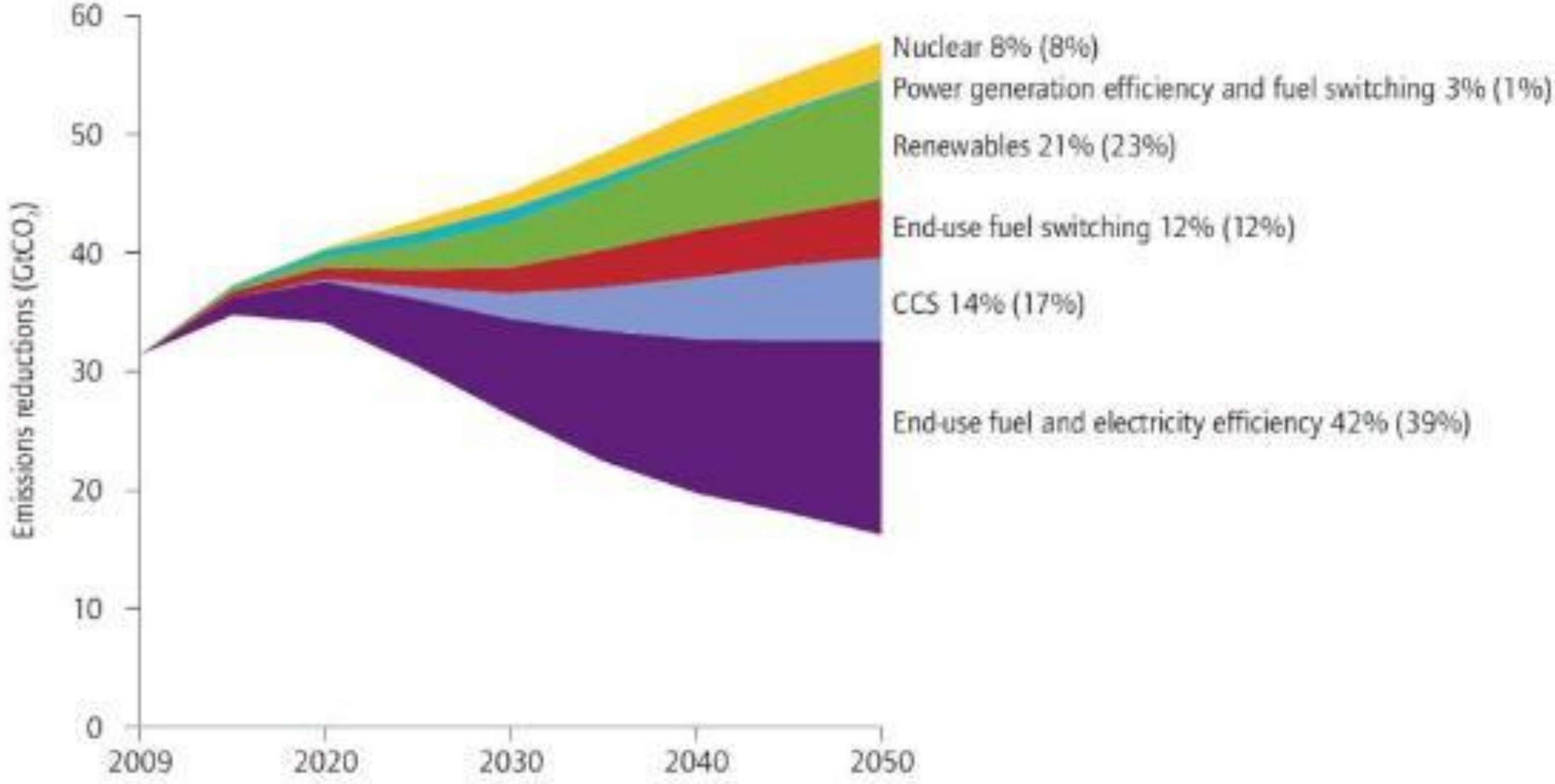


About 50% of available methane can typically be extracted from a coal seam but this can be increased to 90% by further injection of steam and/or nitrogen

Methane can be used for :

- **Small scale power production for domestic and industrial use**
- **Motor fuel**
- **As a source of methane to be added into natural gas pipelines**

The need for CCUS if global climate aspirations are to be achieved *(IEA 2012)*

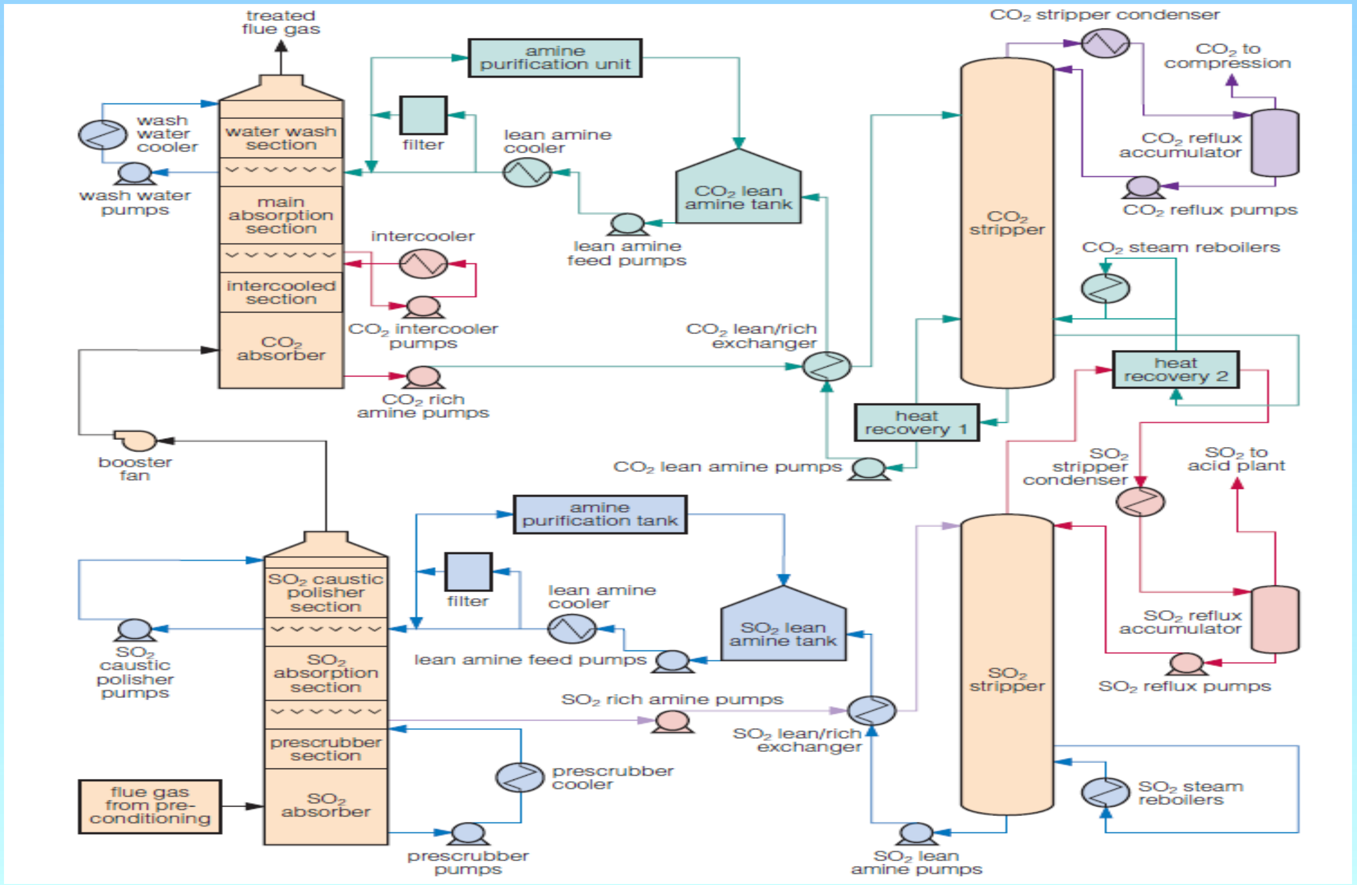


Status of coal power plant CCS large scale operation as of May 2017

- **Boundary Dam 3 (Canada): Started Oct 2014, 120 MWe, amines**
- **Kemper Country (USA): Start mid 2017, 524 MWe, precomb. w/ selexol**
- **Petra Nova at WA Parish (USA): Start 2017, 240 MWe, amines**

Shell Cansolv® integrated SO_2-CO_2 system

- Regenerable aqueous amine-based solvents scrubbing process (Cansolv Technologies, subsidiary of Shell)
- Essentially all SO_2, 90% CO_2 are removed
- Installed at Boundary Dam Unit 3



What's different about CCS?

CCS is a less attractive investment, even for governments:

- **High upfront costs and risks**
- **Complex process chain (often several different technology providers need to collaborate)**
- **Longer deployment time – incl. storage appraisal**
- **Renewables are often modular and can be deployed gradually – less of a step change from small-scale to full-scale**

- **CCS needs its own investment mechanism – difficult to compete with other low carbon energy sources on a level playing field**

- **CCUS offers EOR advantages at demonstration scale compared just to storage**

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New entrants for CCUS demonstration

What should be the way forward for the coal utilisation sector?

Near term:

- Introduce HELE technologies rather than subcritical units
- Examine all subsystems to see potential for improvement and implement changes where cost effective
- Step up the case for coal since it will remain an integral part of the global energy supply, well into the future

Medium term:

- International cooperation and innovation is leading to very high efficiency technologies with low environmental impact, and not only in the power generation sector. These need to be established.
- Also, key need is to ensure an innovatiive business model for commercial scale introduction of CCUS

Longer term:

- Take forward options for alternative systems
- In several cases link in and integrate the coal utilisation process with promising novel and improved CCUS techniques

Thank you for listening!

<andrew.minchener@iea-coal.org>