DEVELOPMENT OF HELE COAL POWER TECHNOLOGIES

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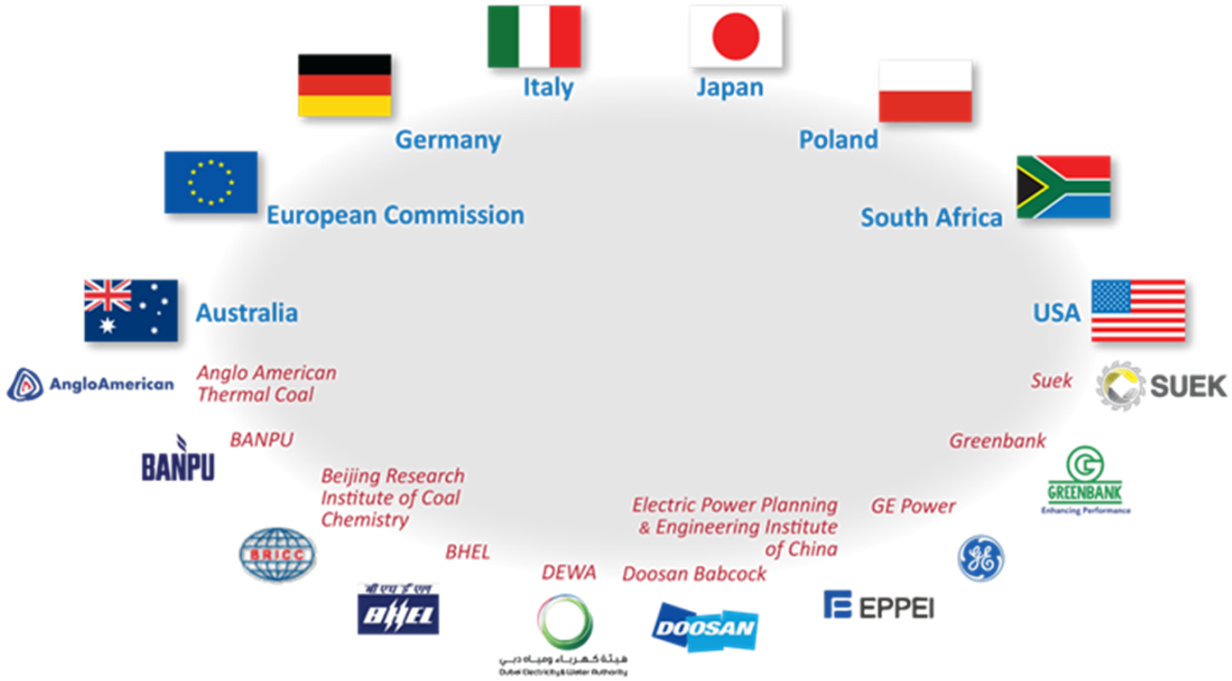
CLEAN COAL CENTRE

WHO ARE WE AND WHAT DO WE DO?



IEA
CLEAN COAL CENTRE

We are an international organisation, endorsed by the International Energy Agency.

We provide independent, objective information on how to produce and use coal more effectively, efficiently and cleanly, to minimise its environmental impact while providing reliable cost effective energy

IEA CLEAN COAL CENTRE WORK PROGRAMME

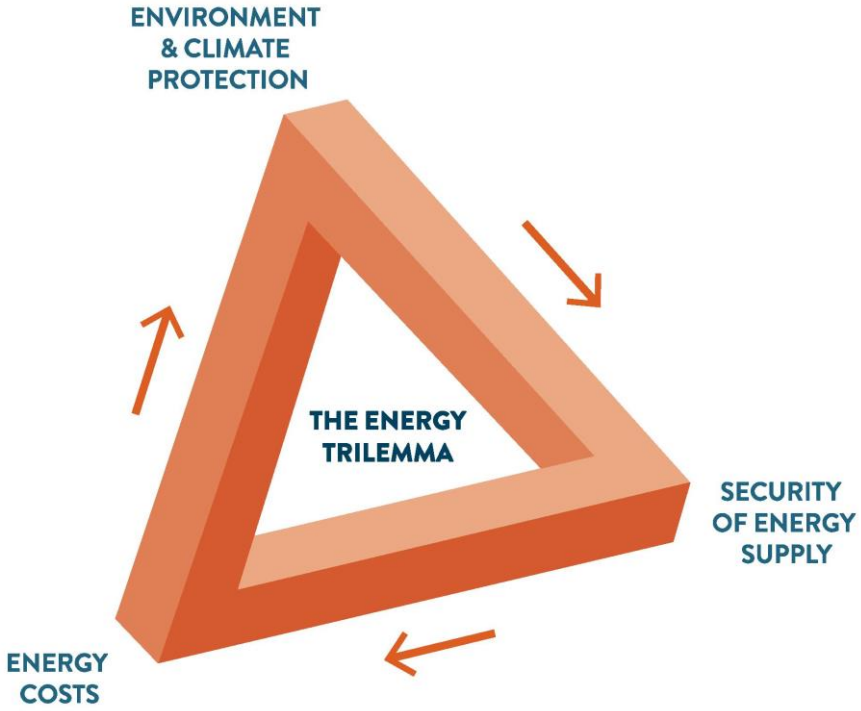
Four interlinked activities:

- Coal based assessment studies, covering both a wide range of technical issues and, increasingly, more policy and regulatory considerations plus global funding issues (~ 60% of resources available)
- Dissemination activities via website, the press and other media sources (15%)
- Outreach activities, increasingly in developing and industrialising countries (20%)
- Provision of specialist support upon request to individual members (<5%)

SCOPE OF PRESENTATION

- Coal and global energy use
- HELE technology options and ongoing developments (high efficiency, low emissions)
- Air quality and emissions control
- Multi-pollutant control technology prospects
- Towards near zero emissions power plants by combining HELE with CCUS (carbon capture, use and storage)

COAL MEETS KEY ENERGY CHALLENGES WORLDWIDE

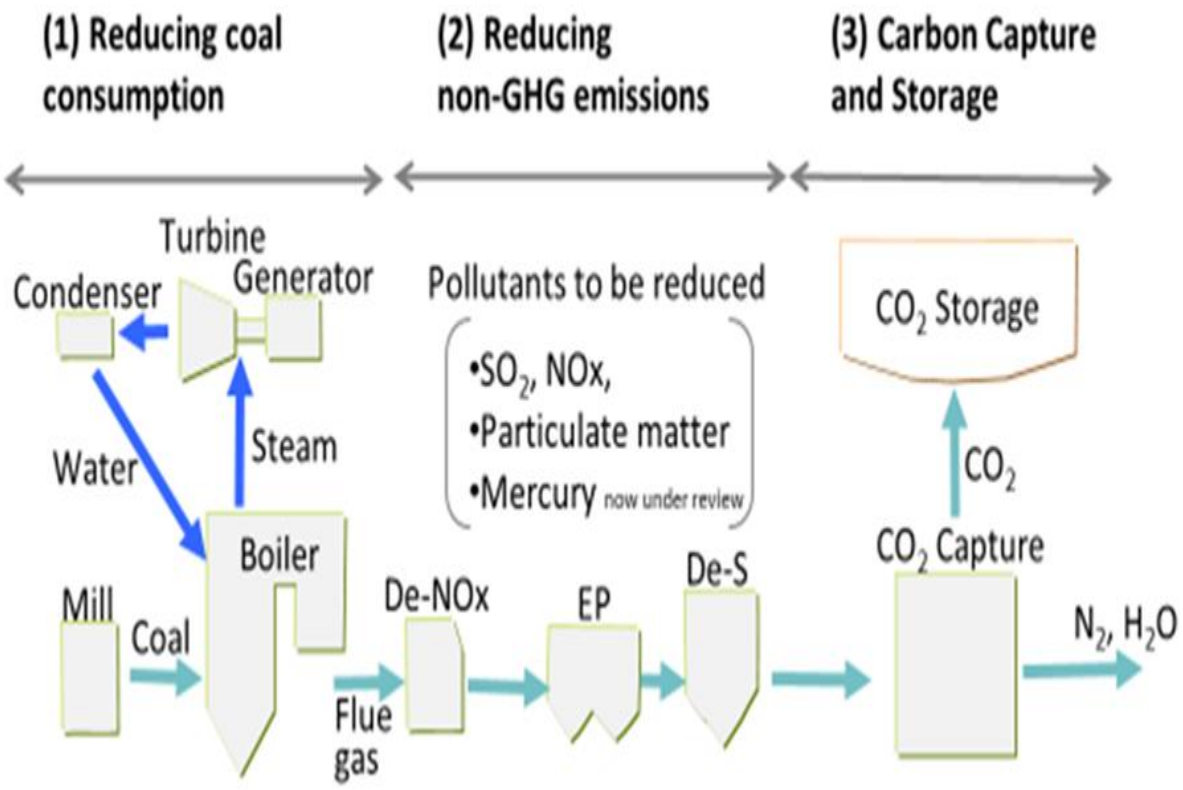


Drivers for coal remain, as a means to lift populations out of poverty and to ensure robust reliable energy sources, for power, industry and chemicals/future fuels production, which will take forward industrialisation in developing countries

- 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 CO_2 from coal, through improvements in efficiency and the subsequent introduction of CCUS

HELE TECHNOLOGY KEY STEP TOWARDS NEAR ZERO EMISSIONS

- Reality is that developing countries are going to use coal, since their prime drivers are energy security 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 CO_2 emissions
- HELE clean coal technology is commercially available and being deployed especially in China, Germany, Japan and Korea
- Development is underway to establish advanced systems that will provide a step change improvement to over 50%



USC COAL POWER CAPACITY WORLDWIDE

(PLATTS, JUNE 2017)

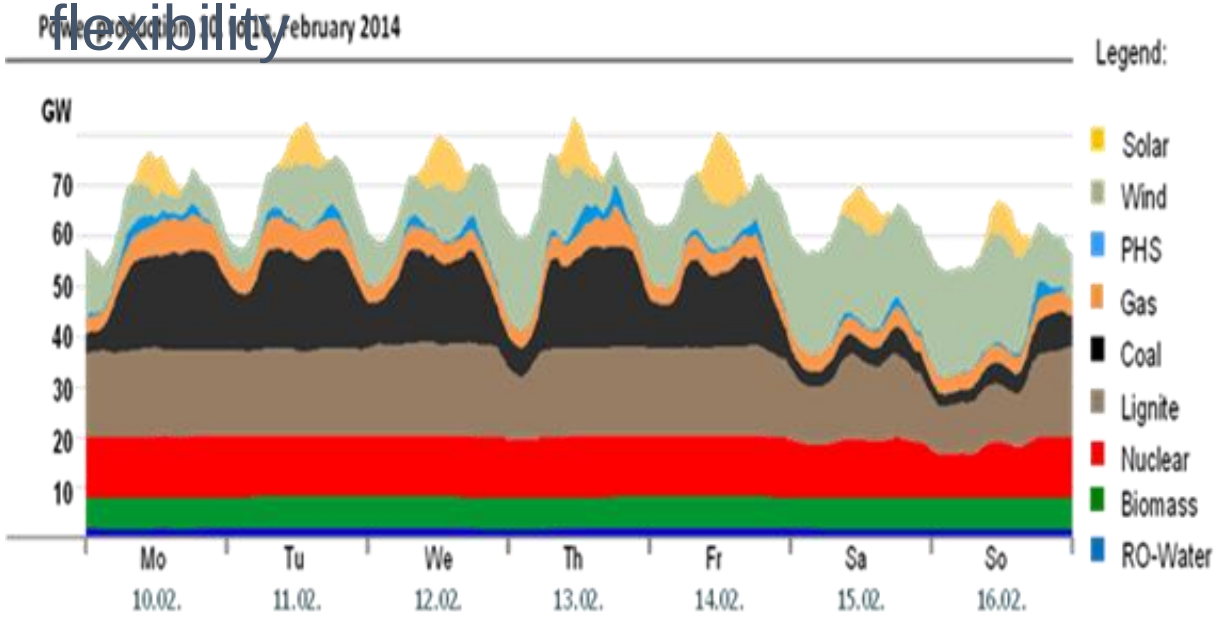
REGION	IN OPERATION (MWe)	UNDER CONSTRUCTON (MWe)
Asia	201413	94575
Europe	24133	6045
Middle East	0	3786
Eurasia	300	0
North America	665	0

THE NEED TO PROGRESS HELE DEPLOYMENT

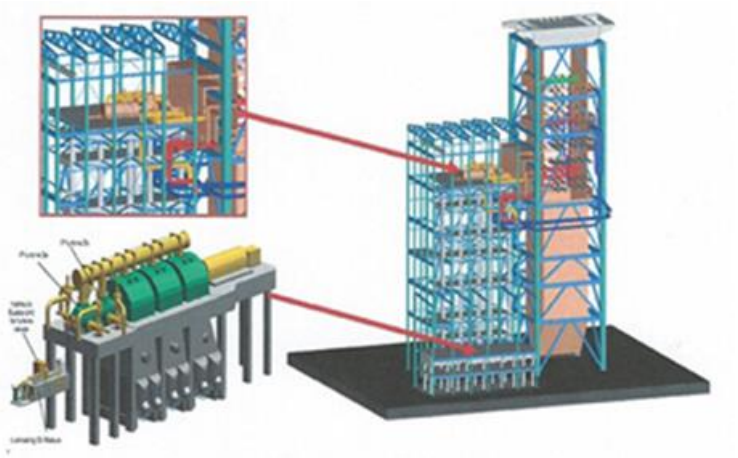
- Need is to increase the proportion of HELE coal power plants built and deployed in place of inefficient, polluting units
- HELE technologies currently include USC, A-USC, and IGCC (in principle), with efficiencies reaching 47% (net, lhv basis), while average global coal efficiency is currently 35%
- Some 40% of world power generation is from coal: huge CO_2 savings possible by using HELE technologies
- Focus needs to be to promote use of HELE plant in the developing world and raise average efficiency
- Adoption of CCUS (once proven) will also be less demanding for HELE plant

ONGOING IMPROVEMENTS TO USC COAL FIRED POWER PLANTS

- Increased operational flexibility



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



- Lower conventional emissions

Emissions (mg/m³)	
Dust:	0.7
SO_2:	15.1
NOx:	17.2

TOWARDS >50% CYCLE EFFICIENCY WITH ADVANCED USC TECHNOLOGY

Programme	Steam temperature	Efficiency (%, lhv, net)	Programme start date	Demonstration plant date and size	Includes:
EU	700ºC	50	1998	2021 (500 MWe)	Coatings, biomass co-firing
USA	760ºC	45-47 (hhv)	2000	2021 (600 MWe)	Oxyfuel, coatings,
Japan	700ºC	>50	2008	2021 (600 MWe)	Biomass co-firing
China	700ºC	46-50	2011	2021 (660 MWe)	-
India	700ºC	>50	2011	- 800 MWe)	-

Metals used in boiler and turbine hotspots:

- Steels well proven in USC at 600°C
- Nickel based alloys proving capable in AUSC at 700°C

ADVANCED COAL POWER TECHNOLOGY IN CHINA

(WWF EUROPEAN POLICY OFFICE 2016)

Technology	Net efficiency (lhv, %)	House power rate (%)	Net coal consumption (g/kWh)	CO2 emissions (gross energy output in g/kWh)
Subcritical	≤ 38.0	4.5-5.5	323.3	798.6-807.3
Supercritical	≤ 42.0	4.0-5.0	292.5	726.5-734.4
600°C USC	≤ 45.0	3.5-4.5	273.0	681.7-689.1
700°C USC	45.0-50.0	3.0	273.0-245.7	623.5-692.8
Pingshan 1350 MWe 600°C USC	49.8	3.5	246.7	622.7
Pingshan design with 700°C USC	53.0	3.0	231.8	588.2

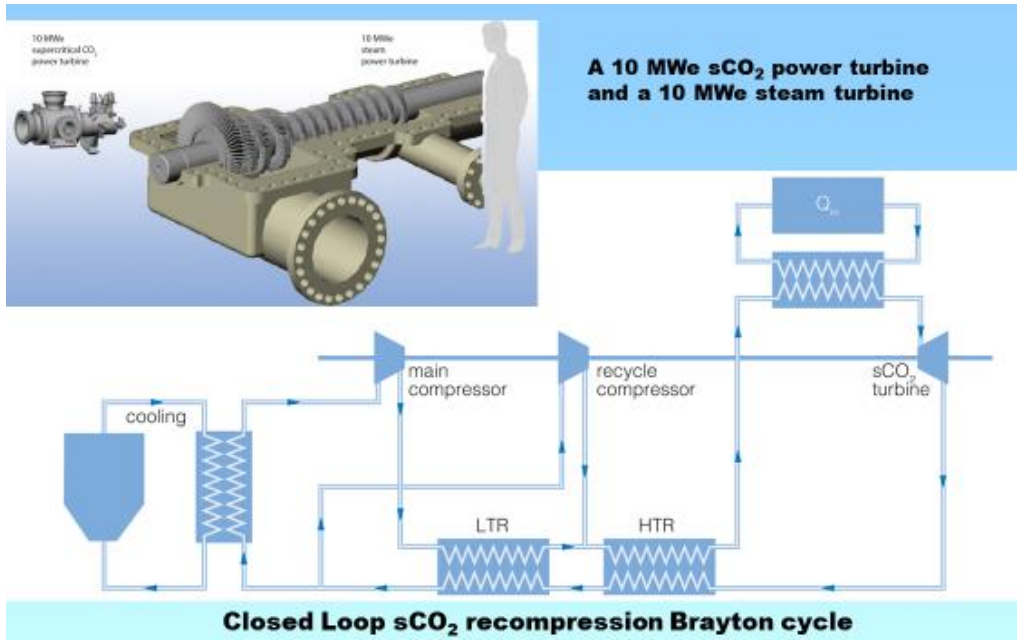
Net coal consumption is based on standard coal with lhv of 29308 kJ/kg

All the data are based on design conditions

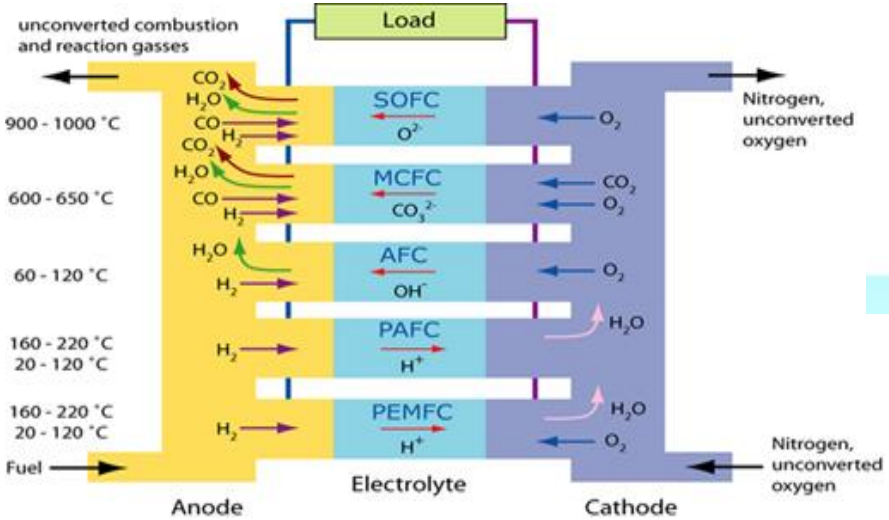
WHERE ELSE MIGHT WE GO FROM HERE?

- IGCC offers potential for high efficiency with very low emissions

- Supercritical CO_2 alternatives to steam Rankine cycles offer a transformational technology with much higher efficiency and potentially lower costs

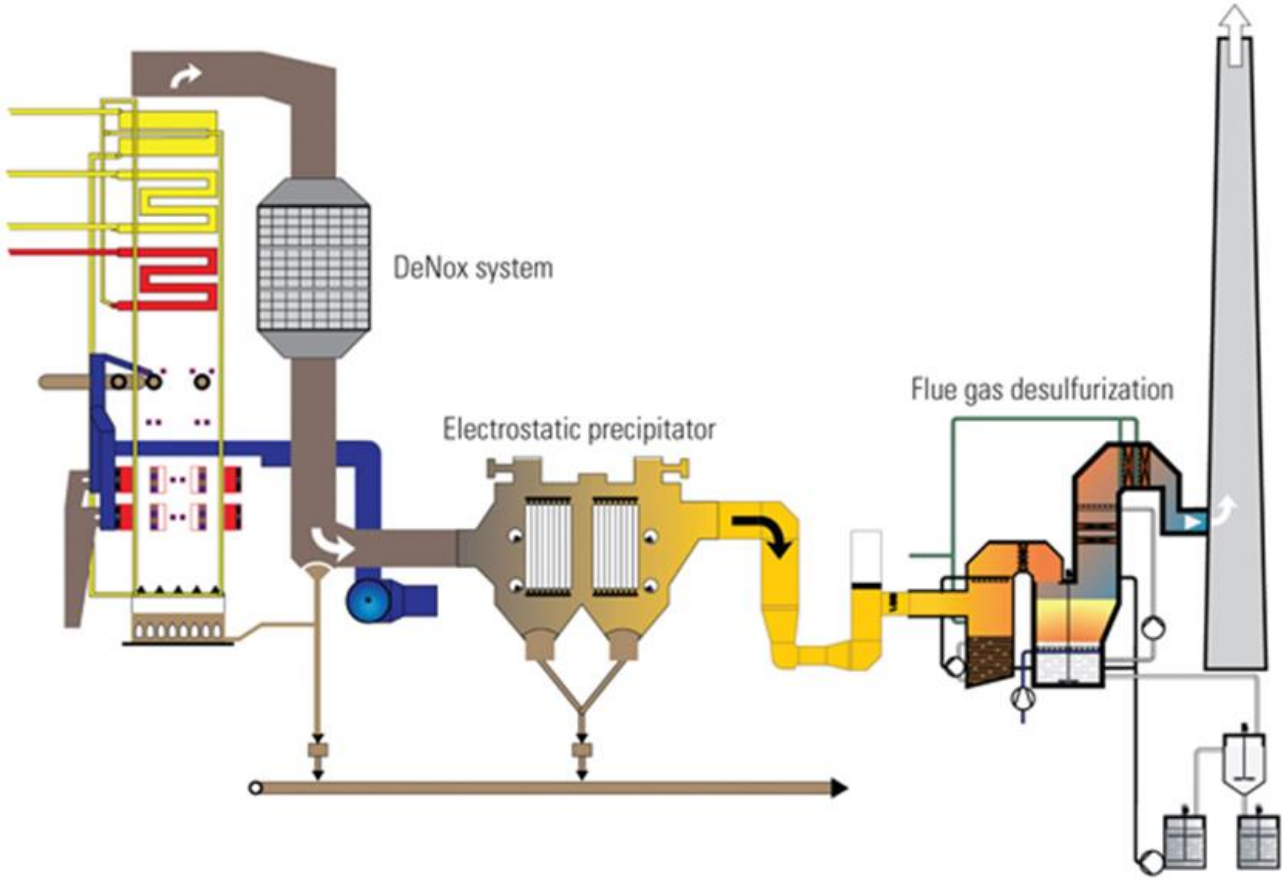


- Fuel cell (FC) is an emerging technology towards-zero emission, high-efficiency coal power plants



AIR QUALITY AND EMISSIONS CONTROL

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



Emissions (mg/m^3)	
Dust:	0.7
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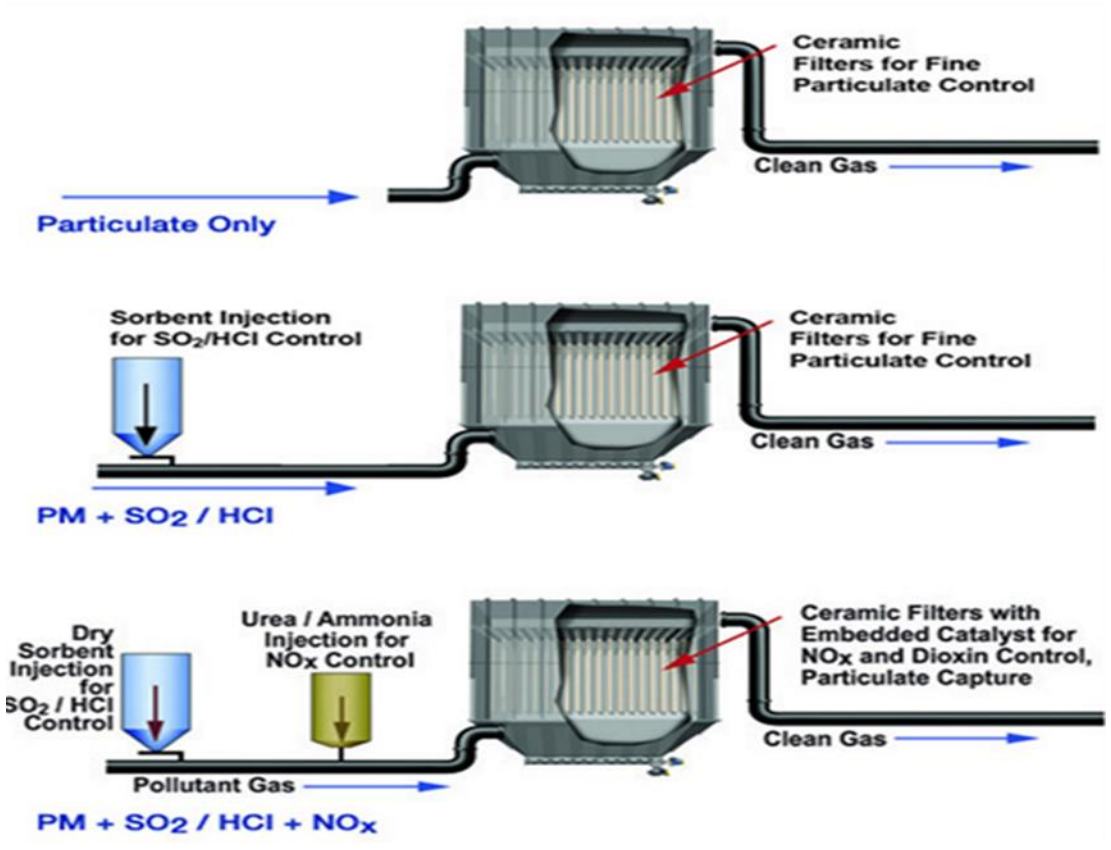
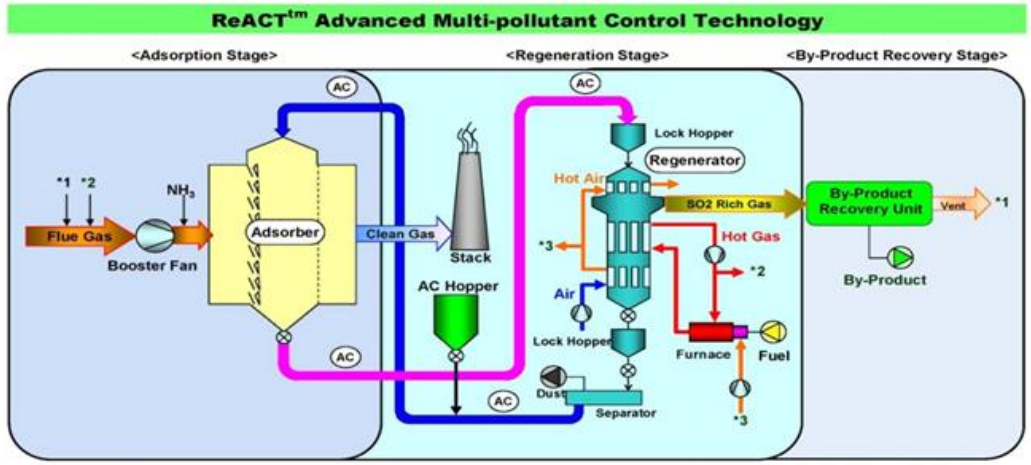
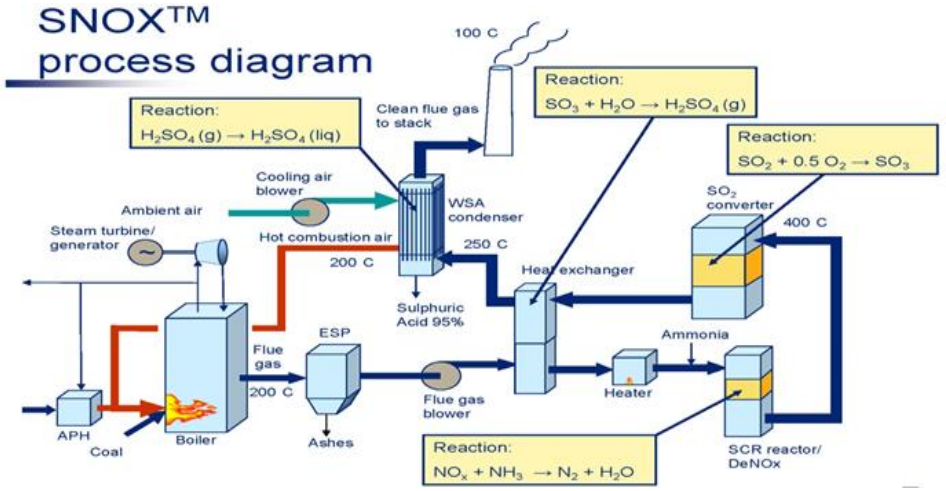
MULTI-POLLUTANT CONTROL TECHNOLOGIES

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

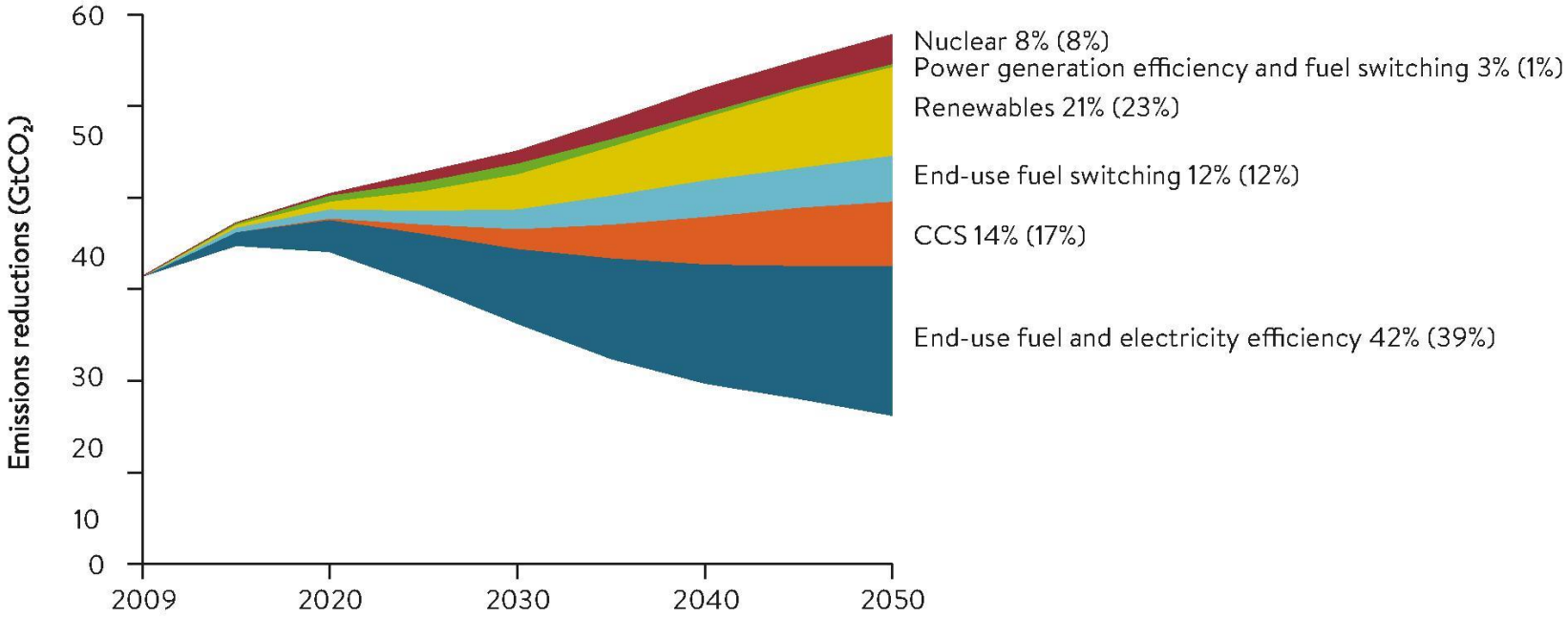






NEED FOR CCUS IF GLOBAL CLIMATE GOALS ARE TO BE ACHIEVED

CCS CONTRIBUTES 14% OF TOTAL EMISSION REDUCTIONS THROUGH 2050 IN 2DS COMPARED TO 6DS



Note: numbers in brackets are shares in 2050. For example, 14% is the share of CCS in cumulative emission reductions through 2050, and 17% is the share of CCS in emission reductions in 2050, compared with the 6DS.

Source: IEA, 2012c.

STATUS OF COAL POWER CCUS SEPT 2017

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

WHAT IS 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 potential EOR advantages at demonstration scale compared just to storage

NEW ENTRANTS FOR CCUS DEMONSTRATION

WHAT IS 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 innovative 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

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THANK YOU FOR LISTENING

ANY QUESTIONS?

Dr Andrew Minchener OBE