energy technologies institute

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Potential Role of Combined Cycle Gas Turbines with Carbon Capture & Storage

Low Carbon Technologies for the UK Energy System

Tuesday 7th November at the SCI, London

Den Gammer – Strategy Manager for CCS

ETI10 TEN YEARS OF INNOVATION 2007 – 2017

Introduction to the ETI organisation

- The ETI is a public-private partnership between global energy and engineering companies and the UK Government.
- Targeted development, demonstration and de-risking of new technologies for affordable and secure energy
- Shared risk

ETI members

bp

CATERPILLAR®

EDF ENERGY

Rolls-Royce

Department for Business, Energy & Industrial Strategy

EPSRC Pioneering research and skills

Innovate UK Technology Strategy Board

ETI programme associate

HITACHI Inspire the Next

Presentation Structure

Introduction to the ETI

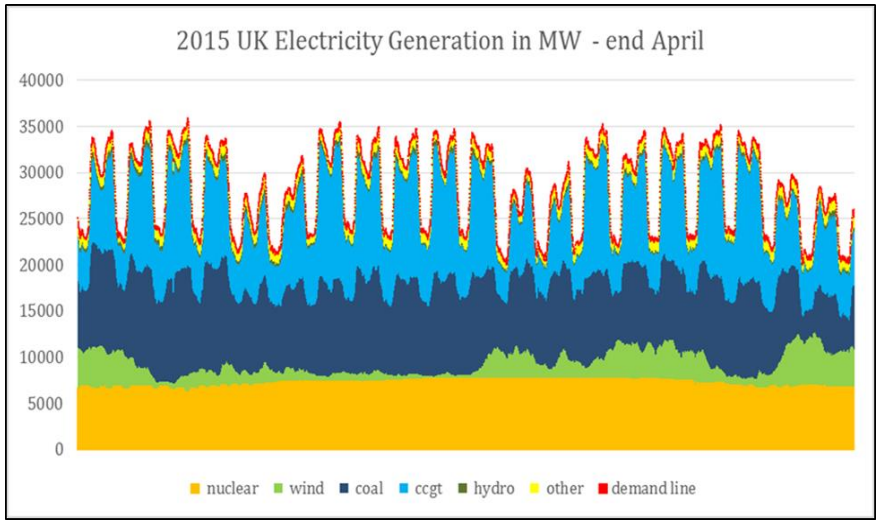
- Large Gas Turbines – prevalence and role in UK power
- Additional plant to add post combustion Carbon Capture and Storage
- Cost, scale and promoting industrial emissions capture
- Performance requirements as renewables increase - 2030
- Alternative oxy –fired and pre-combustion options

Conclusions

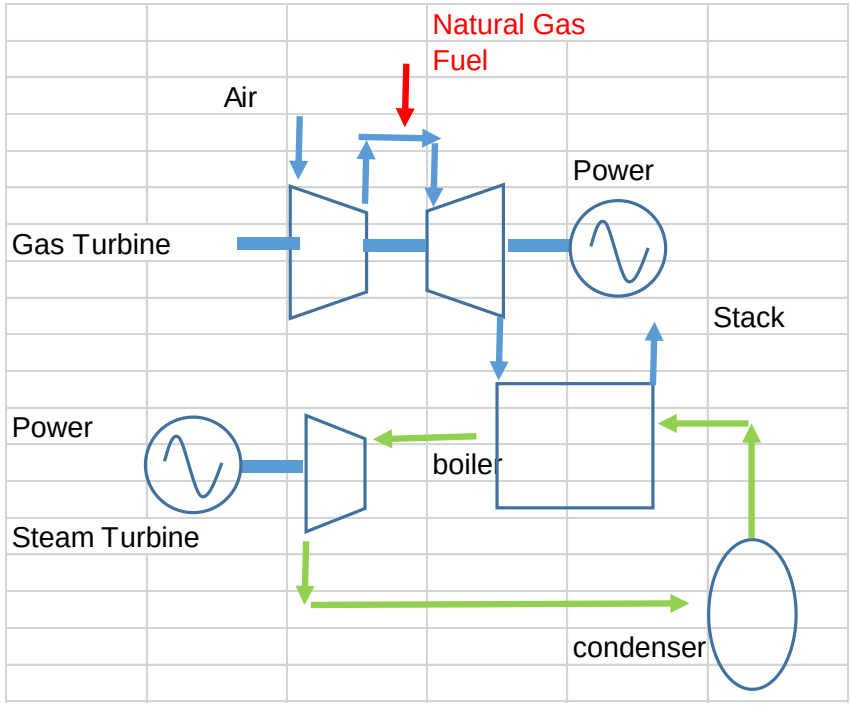
The Combined Cycle Gas Turbine

- Large - 700MWe
- Low capital cost - <£750/kW
- Build time 24 months
- Supremely flexible – ramps, stop/starts
- Efficient
- Clean relative to coal, oil, waste combustion

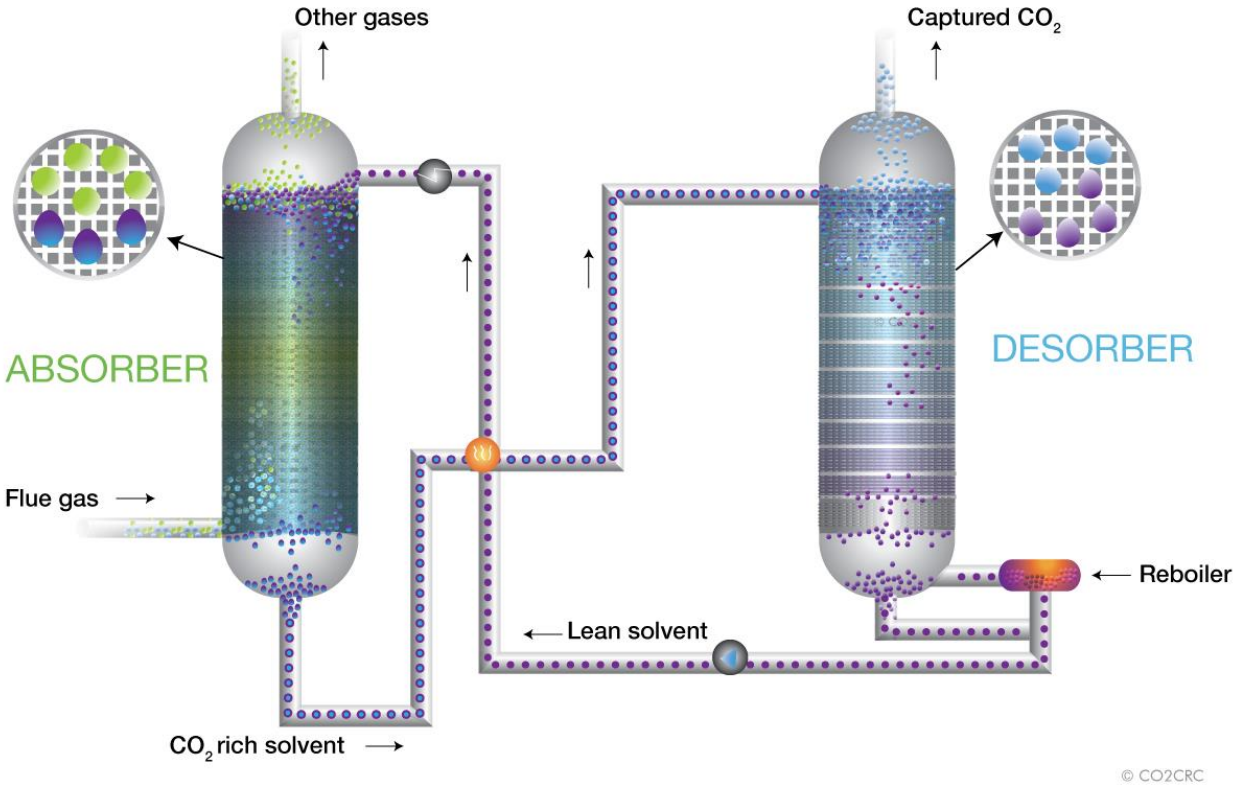
⇨ over a third of UK power capacity



Data : from Gridwatch



Capture plants – example post combustion capture

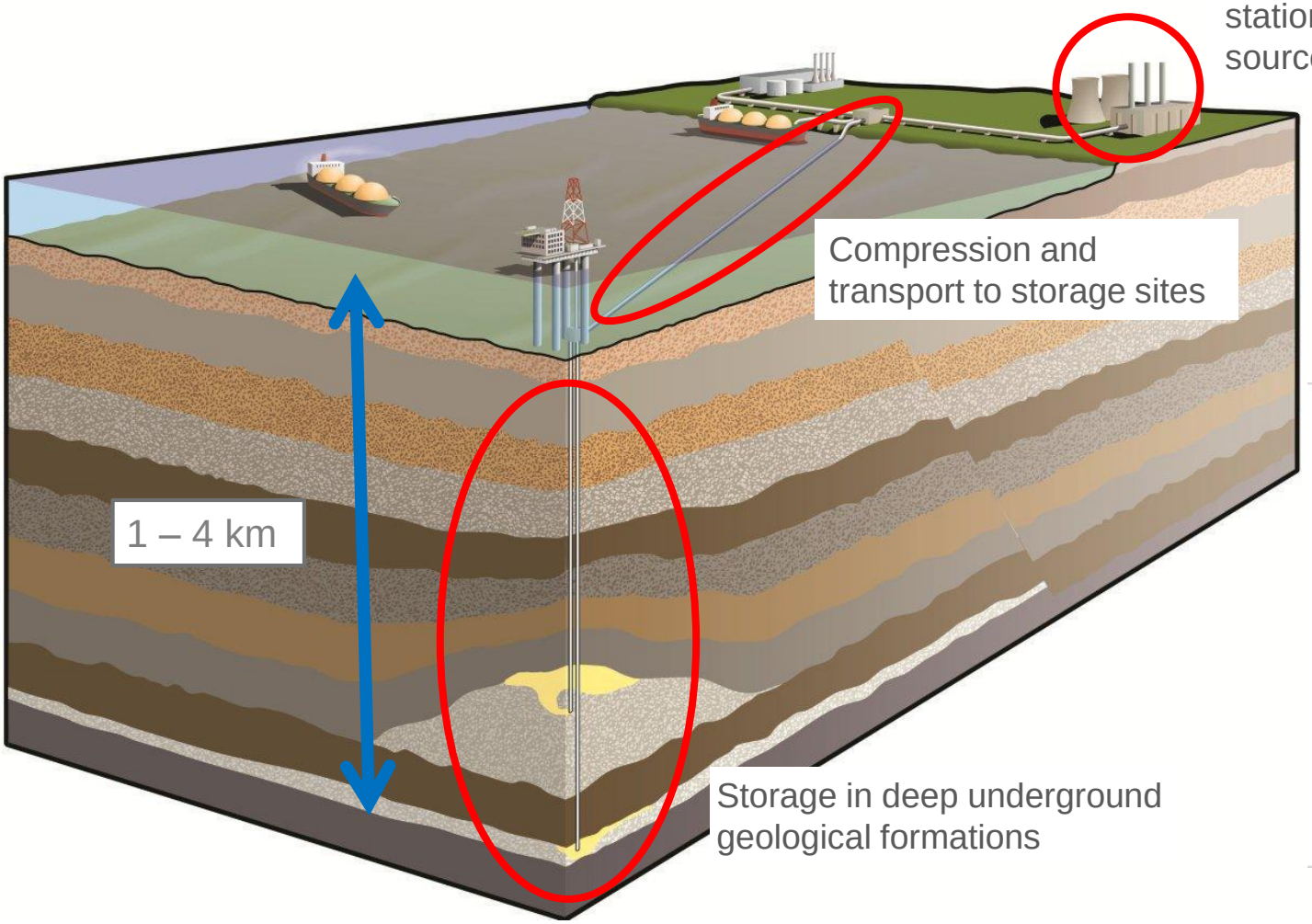


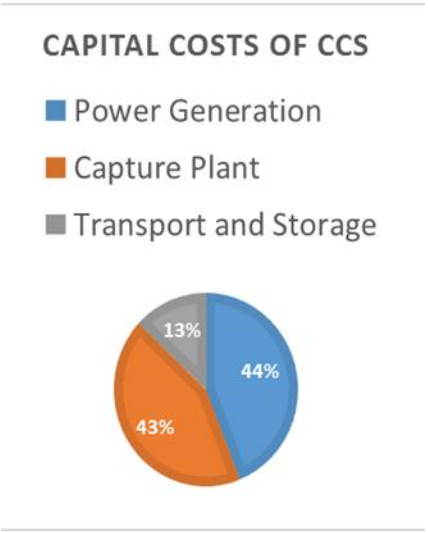
- Enough gas to fill a balloon every few seconds
- Pressure drop is expensive !
- Must remove 5 molecules in every hundred across 2 phases

Pictures Courtesy of CO2CRC

Additional Plant for a CCS Chain

Capture of CO_2 from power stations & major industrial sources





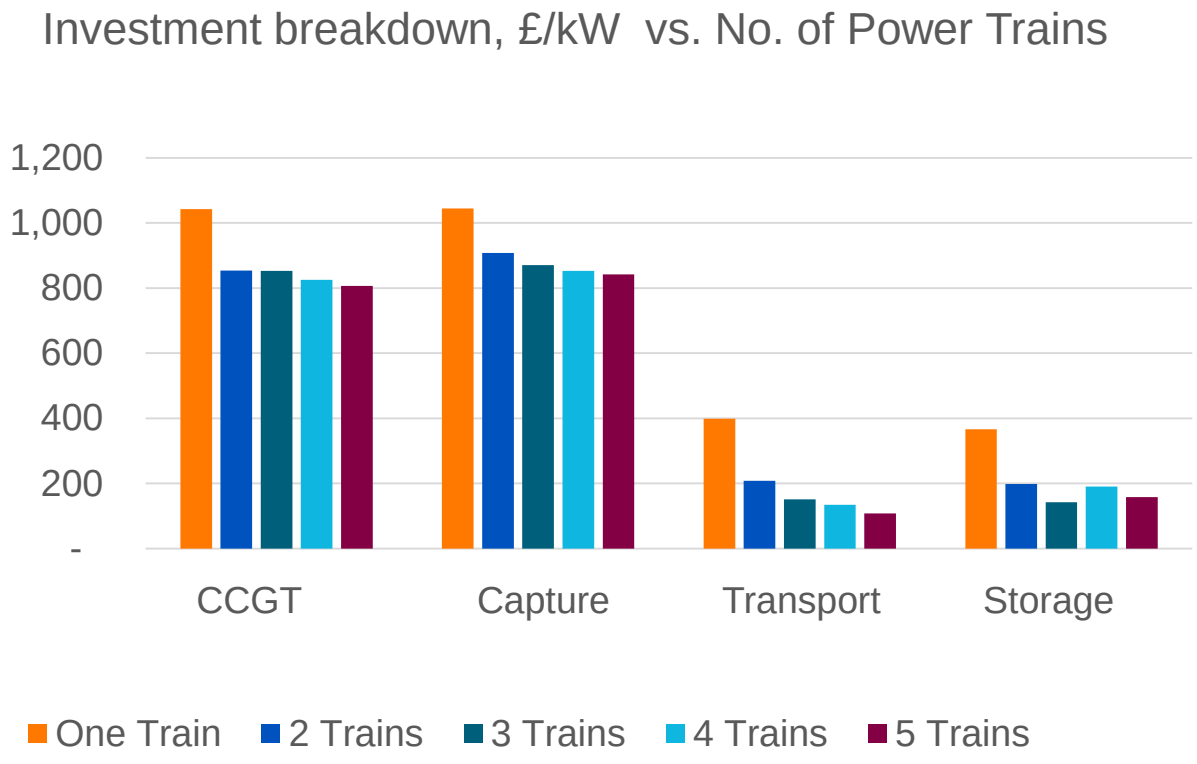
Capture plants – economics

Additional Cost for CCS	CCGT (2010)	CCGT/ CCS
Capital Cost /kWnet , £	550	1240
Efficiency LHV,%	58.8	49.9
Levelised Cost of Electricity (LCOE), £/MWh	48	70
Levelised cost at 40% Load ,£/MWh	70	119
Levelised cost of Fuel Only ,£/MWh	34	40

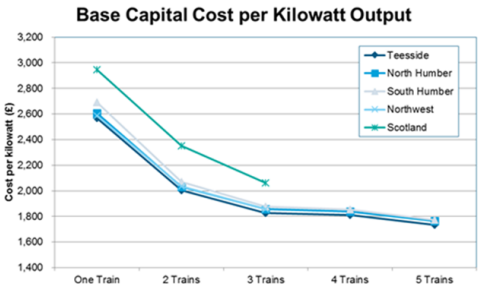
- 17 large scale CCS plants in operation
- CCGT with CCS proven at Bellingham ,USA . Closed
- New power stations fitted with CCS are all COAL
- Capture from steel, ethanol, H2 – all demonstrated at scale.
- Natural Gas cleaning – Sleipner 1996 !

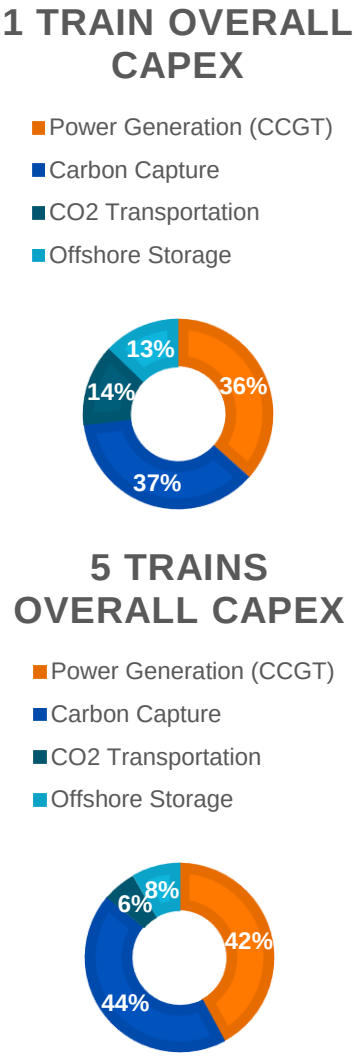
Discounting at 10%, with a 20 year lifetime for gas plant and 30 years for coal plant. Costs are for mature “nth of a kind” plant and include a contingency of 25%. The plants run with an 85% load factor. Gas at £265/te and coal at £65/te. Carbon at £0/te

Breakdown of Investment

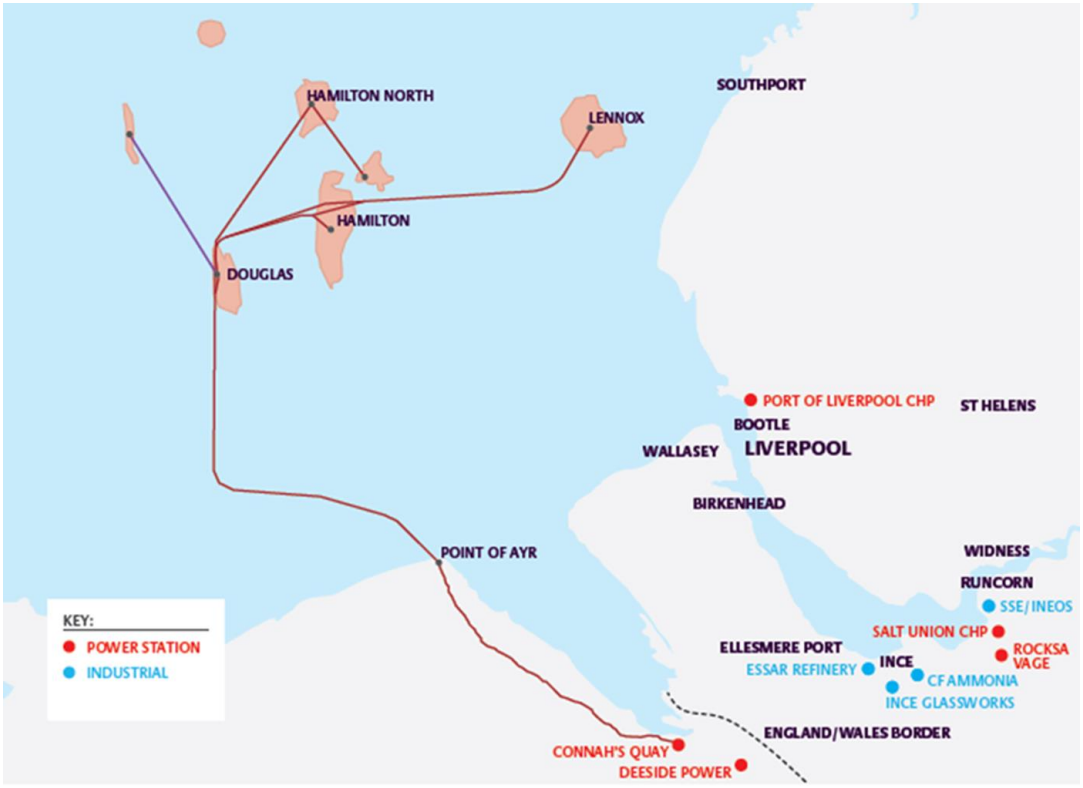


Scale helps – Each train about 2MT/a CO2





CCGT/CCS builds transport and storage at scale – admits industrial emitters



Example

- CF Ammonia – 0.33Mt/a -CO_2 Transport and storage costs to Hamilton Store - £324M
- Single GT Connah's Quay - 1.5Mt/a CO_2 Transport to Hamilton Store - £255M
- CF Ammonia – 0.33Mt/a – CO_2 Transport and storage to Connah's Quay - £56M* or £37/te plus rent

* Costed as a high pressure (small diameter) line

Pitching CCGT/CCS into the future fleet

- Selected three “fleets” for 2030 and 2040

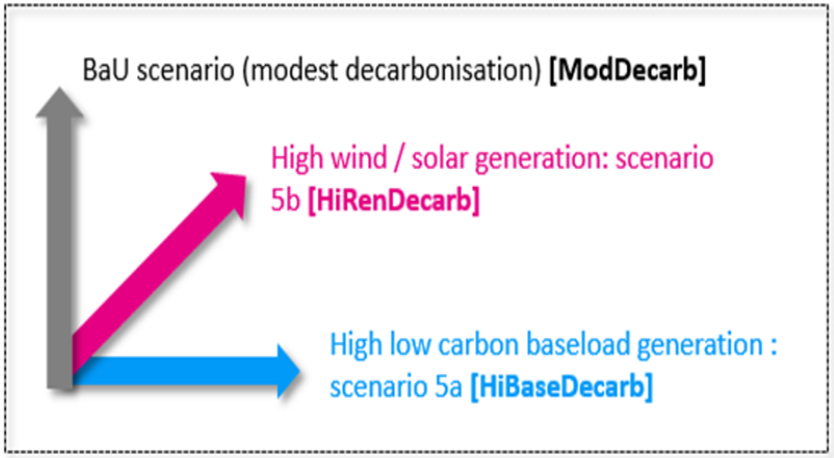
  - Modest Decarbonisation effort – BaU
  - High Renewables
  - High Nuclear/ Some CCS - high “baseload”

- Run half hourly despatch model – Plexos in Wholesale Market Mode

- Despatch on short term cost basis

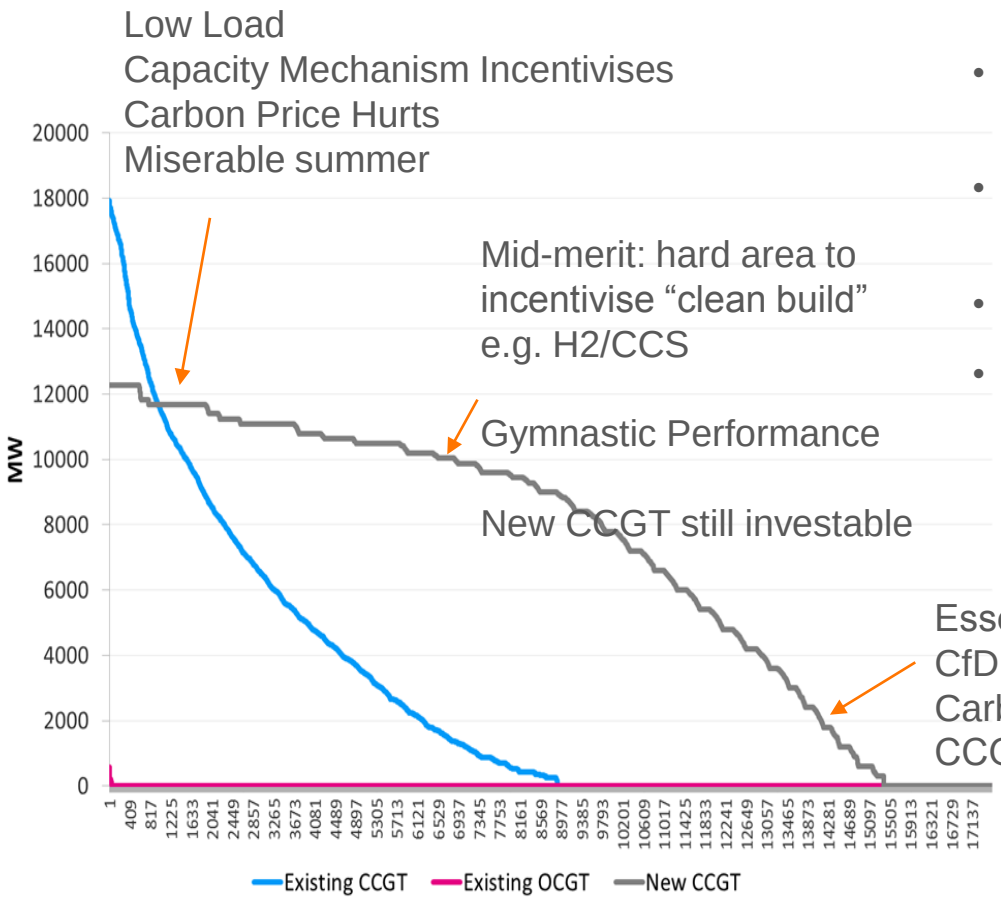
- Extract
  - stop/start requirements
  - ramp rates etc
  - total gas use

- Investability - Plexos in Asset Evaluation mode - Annual revenue, then back-check investability



Despatched Gas Fired Fleet Profile - 2030

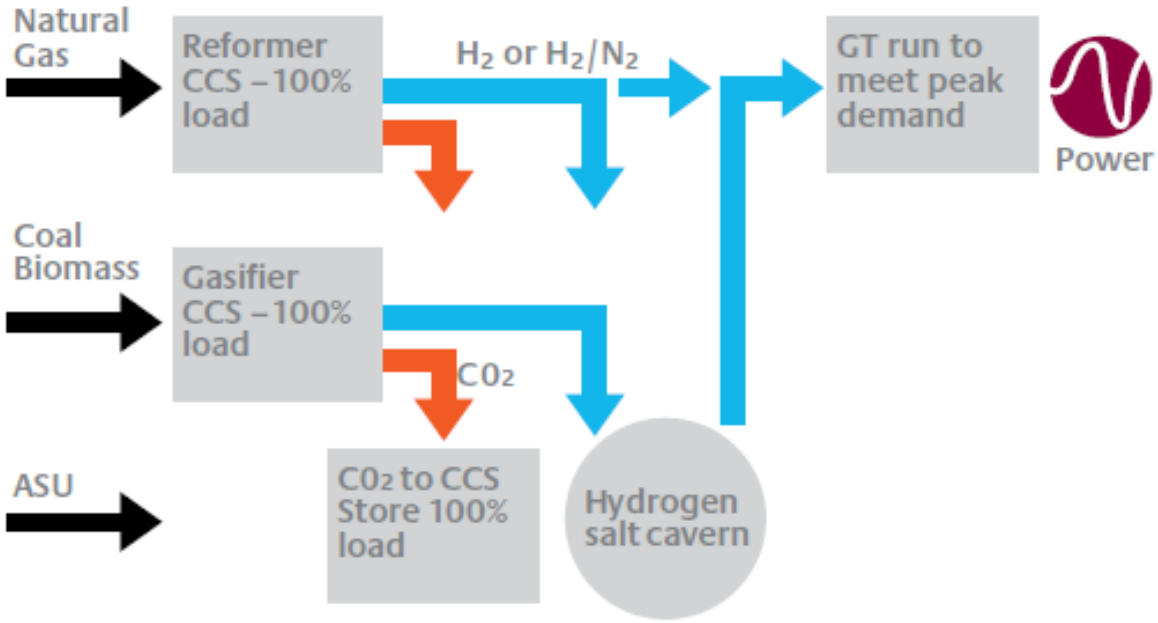
"BAU" – Modest Decarbonisation Case (NG FES)



- 4GW 'baseload' taken by CCGTs (plus CHP not shown) – opportunity for CCS
- When added into model, 3GWe CCS was despatched, displacing GTs
- Flexible despatched MWh exceeded the Baseload MWh
- Long tail of older plant ave 16% Load Factor
- "New" Post 2016 fleet ave 58% Load Factor

Using H2 storage to maximise use of CCS investment

Power station configurations using H_2 storage



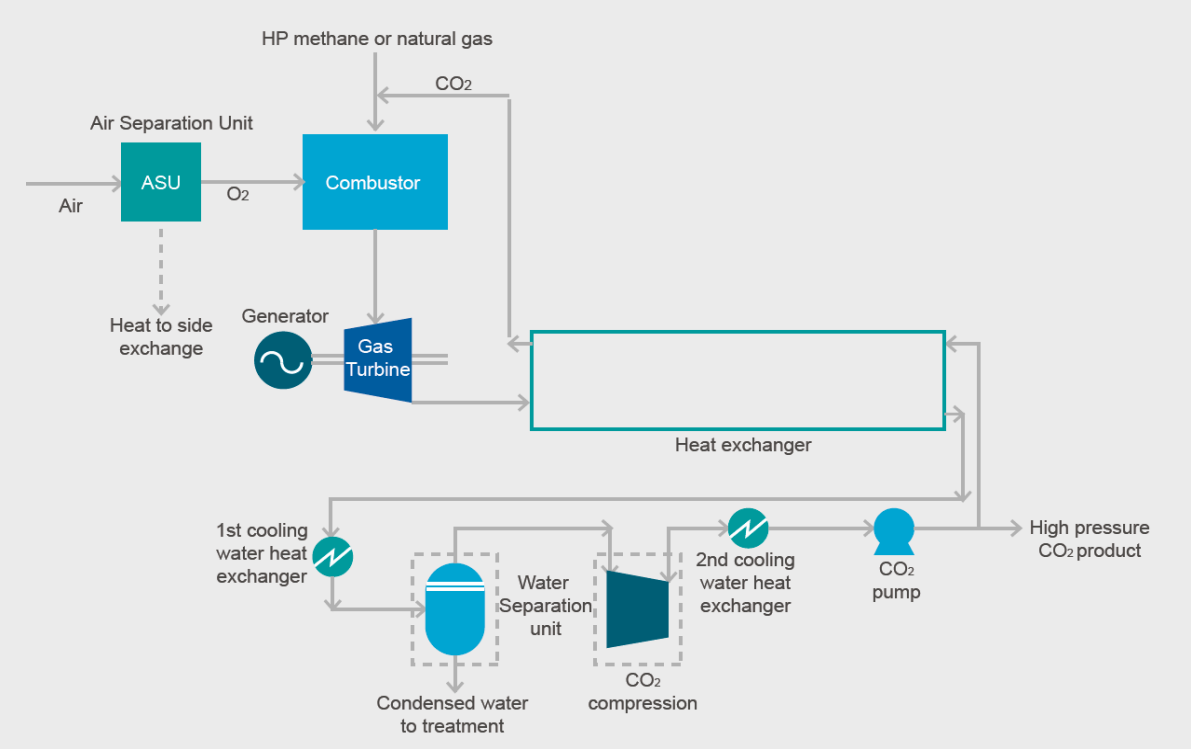
UK salt beds are not widespread
but are situated in good locations

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

amec foster wheeler

Pre – combustion and Oxy Combustion (NET Power)

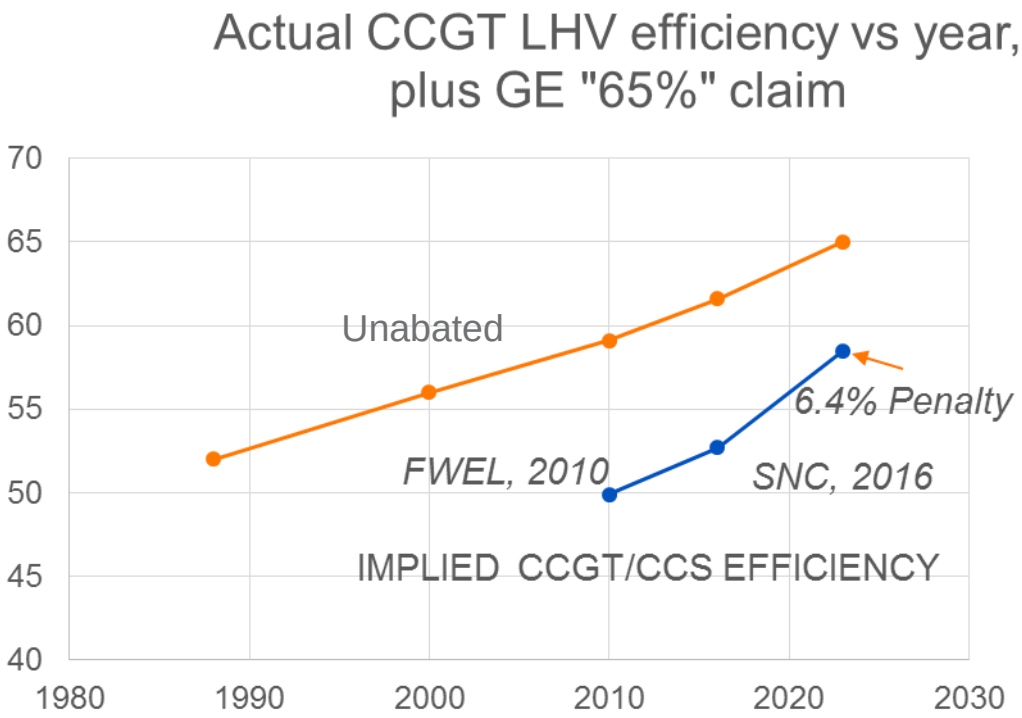
- New power cycle designed with CO_2 capture in mind – no steam cycle.
- New Combustor and Turbine type – high pressure/medium temps (300 BarG, 1180 oC)
- High level of heat recuperation, high outlet pressure of turbine (~ 30 BargG)
- Target 58.9% efficiency , same capex as unabated CCGT



- High pressure means
  - small !!
  - CO_2 pumpable
- Oxy –firing means
  - CO_2 /H_2O only (ish)
- 50MWth unit under construction, Texas

CCGT/CCS – Performance & Cost Trajectory

- Large increase in scale of GTs since 2010
- Both cost and efficiency improvements
- Post combustion capture energy penalty is also reducing
- Capital cost of capture – expecting 20% reduction post PetraNova, Sask Power



The Clean Gas Project

OIL AND GAS CLIMATE INITIATIVE

2016/2017

- ETI develops concept – large scale, first commercial gas with CCS plant, without capital subsidy

Mid 2017 onwards

- Clean Gas Project transferred to OGCI Climate Investments
- Announced at OGCI CEO's meeting, 27th October 2017

Conclusions - Energy Mix - a team

BASELOAD

- Bullet Proof
- Dependable
- Large

Nuclear, Coal /Gas CCS

RESPONSIVE

- Ready for action
- Flexible Role
- Multiple Skills

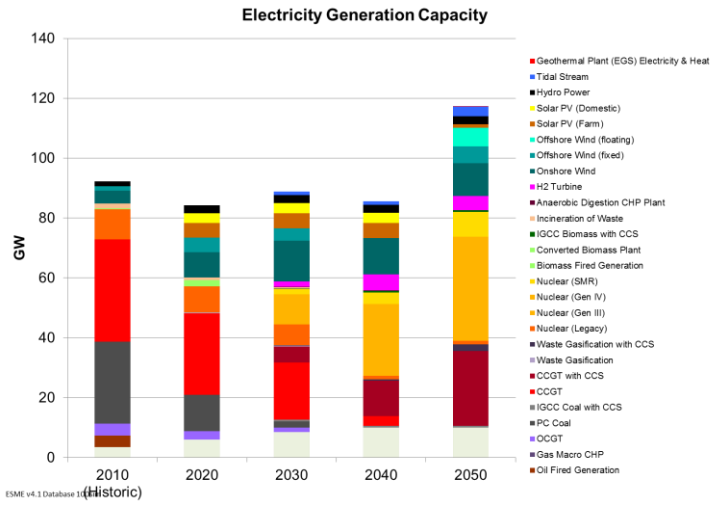
Gas or gas/CCS, Diesel

INTERMITTENT

- Clean
- Less predictable
- Low operational cost

Wind, Solar

Key Messages



CCGT/CCS offers system wide benefits to the UK energy sector

- Provides clean power on demand.
- Infrastructure support for industry, and through H_2 possibly heat and transport emissions
- Cost advantage – without CCS, energy would be more expensive in the UK - 2050 system costs up £30Bn+/a, electricity up 2p/kWh.

Key challenges

- New business models and financial solutions, for complex projects required.
- Cheaper capture technology, through demonstration projects and innovation.

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A showcase of a decade of research

ETI10 | TEN YEARS OF INNOVATION 2007 – 2017

County Hall, London
21st and 22nd November

Register online at - www.eti.co.uk/10Years

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