Department for Business Innovation & Skills

UK perspective on Industry CCS Technology readiness and costs

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UK perspective on Industry CCS

- Introduction
  - UK context
  - Industrial clusters
  - UK Industrial CCS policy
- Technology readiness of industry CCS
- Costs of carbon capture from industrial sources

UK context

- UK Government legally required to reduce carbon emissions by 80% of 1990 levels by 2050.
- 23% of emissions came from industry in 2009 – 131.6MtCO_2. 80% if this is from production of heat needed for industrial processes
- UK Carbon Plan anticipates need for 70% reduction in industrial emissions by 2050 to meet 2050 targets

UK Context

CCS

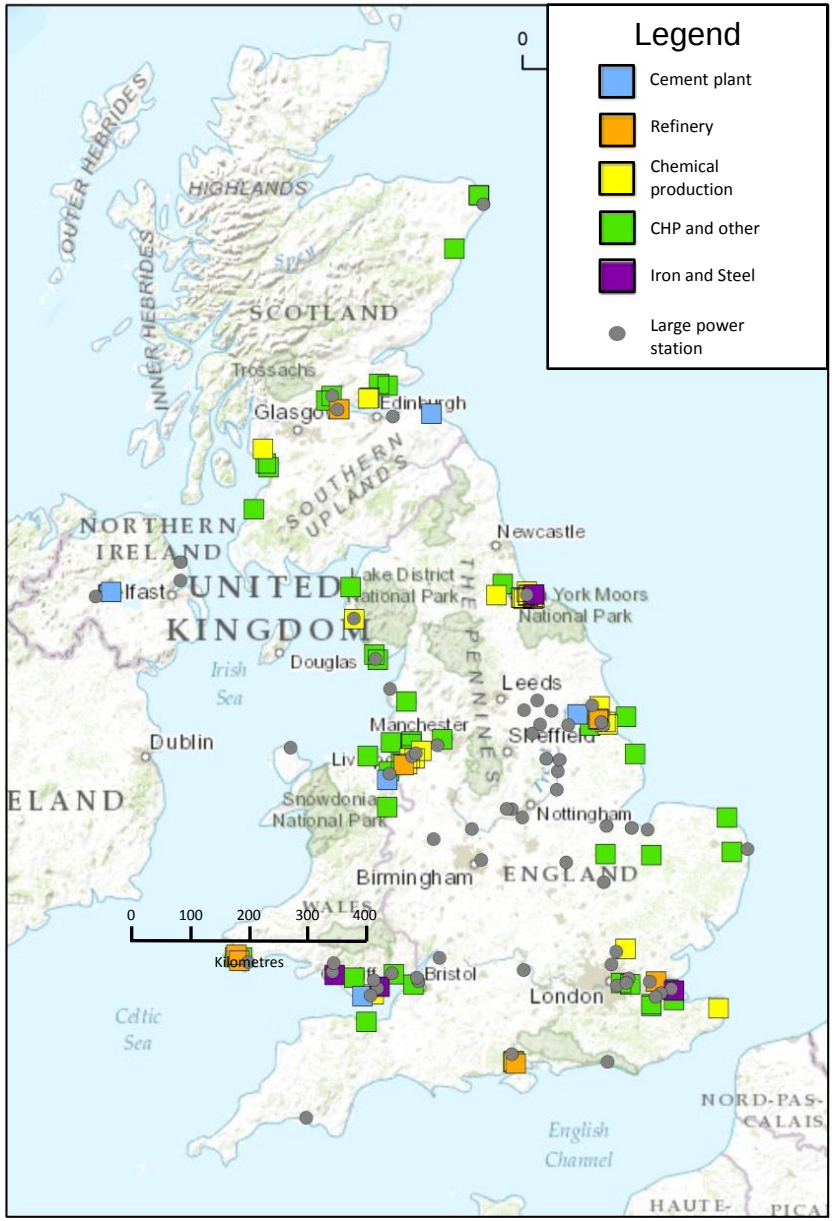
- £1bn commercialisation competition
  - Focused on power sector but industrial CCS also eligible where it can link to a power emitter, and contribute to the objective of reducing the costs of fossil fuel power with CCS
- £125m CCS R&D Programme
  - ~85 projects; including some which relate to industrial CCS

Energy Intensive Industries

- Costs of carbon emissions for some industries will continue to rise.
- Some compensation for EU ETS and Carbon Price Support costs but long term solution needed

Industrial Clusters

- High emission industries often clustered together
- Major clusters in Teesside, Humber, etc
- Potential for CCS clusters



Map illustrates locations of existing large UK CO_2 emitters near shorelines that may be relevant for CCS deployment in the period up to 2030. Locations of selected fossil power stations are also shown as these may provide opportunities for shared CO_2 transport and storage infrastructure.

Source: Element Energy

UK industrial CCS policy

- The Carbon Plan envisages a roll out of industry CCS in the 2020s, with up to one third of industries emissions captured this way by 2050.
- DECC published CCS roadmap in April 2012.
  - Government commitment to “Working with the industrial sector to identify the current state of innovation on CCS and the potential for Government interventions to enable deployment”
- UK CCS Research Centre set up on 1 April 2012 carrying out review of technical aspects of industry CCS
- Element Energy updating cost estimates for Industrial CCS

Technology Readiness of industrial CCS

- Series of technical workshops with industry, academia and government at end 2012:
  - Iron and Steel
  - Cement
  - Glass and other industrial heat users
  - Chemicals and refineries
  - Clusters – transport and storage
- Details are available on UKCCSRC website - http://www.ukccsrc.ac.uk/meetings-events/ccs-industry-workshops

Iron and Steel

Emissions

- Large iron and steel works alone responsible for 18.3MtCO_2/year – almost 30% of industrial emissions

Technology readiness

- Several capture choices, option will be site specific
- Pilot ready for some applications
- Some knowledge transfer from power capture technologies

Remaining issues and barriers

- Multiple sources of CO_2 – blast furnace, stove, coke, power station
- Impurities in gas streams
- First Of A Kind risk
- All solutions need to be retrofit – very unlikely will invest in new build in the UK

Cement

Emissions

- UK cement works emit 6.5MtCO_2/year

Technology readiness

- Technology is pilot ready with several pilots planned around the world (none in UK)

Remaining issues and barriers

- Multiple sources of CO_2
- Air leaks in existing plants (for oxyfuel CCS)
- Unknown impact on the quality of the cement of the most highly-integrated methods, though this is not an issue with post-combustion capture.

Glass and industrial heat

Emissions

- CHP is responsible for 17.2 $MtCO_2$/year – 27% of industrial emissions, used in wide variety of industries including glass.

Technology Readiness, remaining barriers and issues

- For glass:
  - CCS one option, but could also reduce CO_2 onsite through fuel switching (electric or H_2) but electric heating thought more expensive than CCS.
  - Oxyfiring used to some extent now for process improvement, but oxy-fuel CCS would require new or substantial rebuild – big cost implication. Some gaps where knowledge is very low.
  - H_2 firing and post-combustion capture thought technically feasible but no experience in the UK

Chemicals and Refineries

Emissions

- Refineries are a major emitter – 16MtCO_2/year or 25% of total industrial emissions.
- Ethylene, Ammonia and Hydrogen relatively low proportion of total UK emissions (2.5, 0.7, 0.2 MtCO_2/year)

Technology Readiness

- Mixture of well developed technologies already in operation (e.g. hydrogen) through to very early stage research (e.g. olefins)

Remaining issues and barriers

- Main barriers where technology is developed are commercial - cost, fuel uncertainty, payback

Clustering, transport and storage

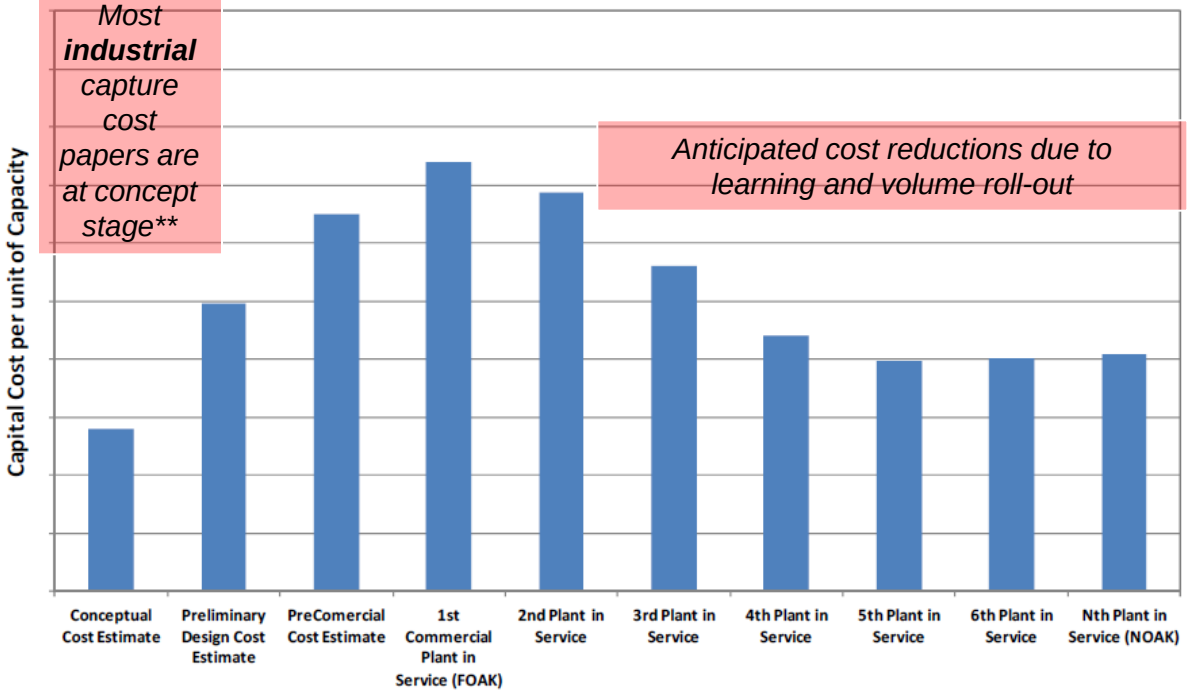
- Having existing pipeline with known costs greatly reduces project risks
- As shown in earlier map, significant industry near to power. Power could therefore be “anchor projects”
- Issues to be resolved around mixing of CO_2 from different sources (design codes, impurity interactions)
- Industry CCS could provide benefit to system as steady supply if power emissions fluctuate reflecting intermittent renewable generation

Costs of carbon capture from industrial sources

- Element Energy have reviewed literature and recalculated capture costs based on most current evidence.
- (Transport and storage costs will follow)
- Number of issues with getting accurate costs:
  - Conceptual cost estimates: little/no cost data from FEED studies to give more accurate results
  - Few papers: Most papers use the same few sources of data on costs – i.e. a lack of papers
  - Old numbers: most papers use data which is now several years old – the costs data has not caught up with more recent advances
  - Site specific variance: e.g. source of heat for the capture process makes a massive difference

Costs – conceptual and uncertain

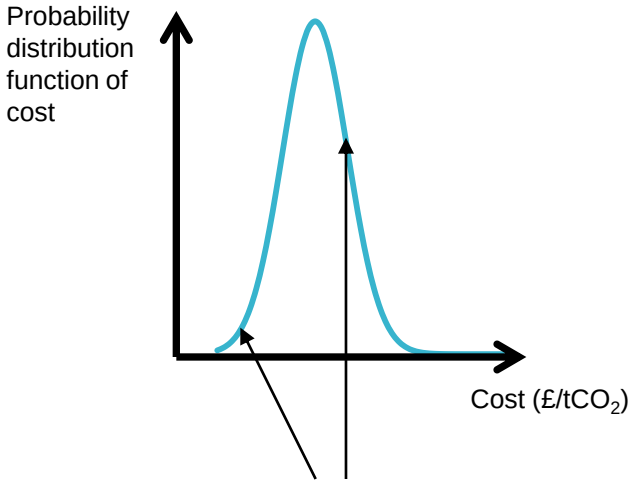
*Most **industrial** capture cost papers are at concept stage***



Anticipated cost reductions due to learning and volume roll-out

*Published capture cost estimates for **power** CCS are now at detailed design*

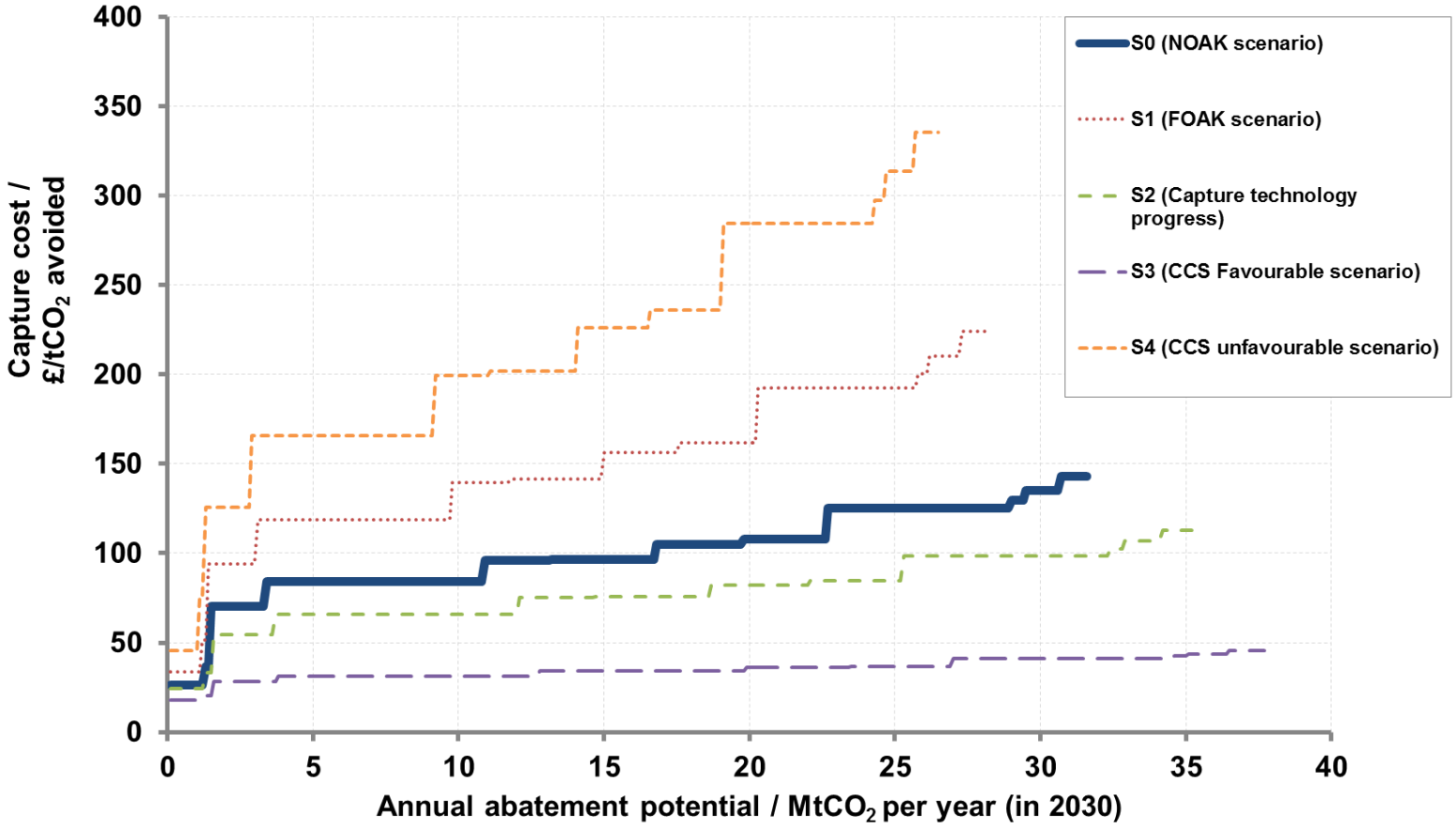
At any given stage there are an inherent cost *uncertainty* and *variability*



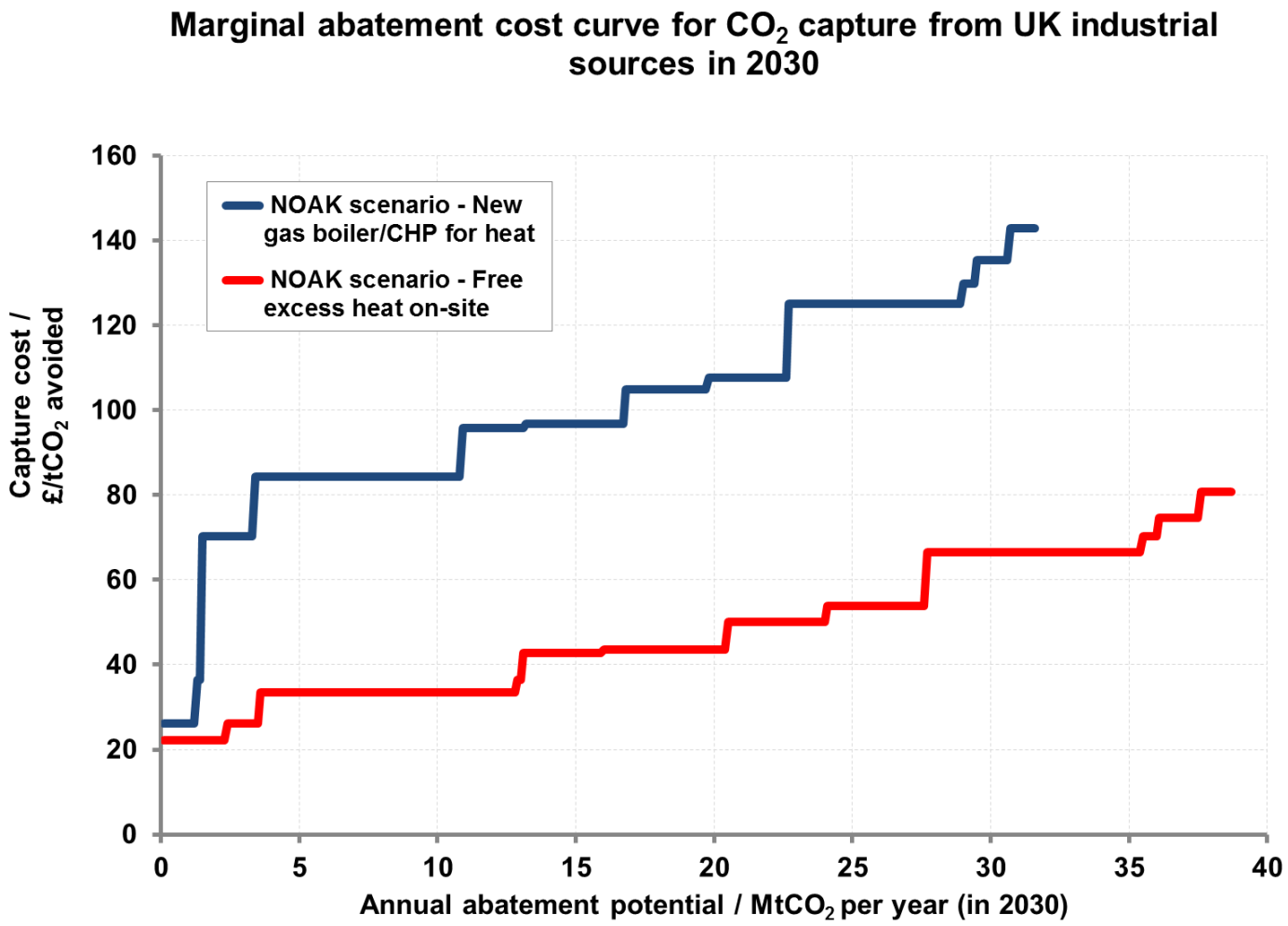
** Capture from ammonia and hydrogen sources is considered mature

Source: NETL, Technology learning curve (FOAK to NOAK) Quality Guidelines for Energy Systems Studies, 2012

Marginal abatement cost curve for CO_2 capture from UK industrial sources in 2030



Impact of heat source assumption on cost



Conclusions of research

- Complex picture with different technology needs in each sector
- Several technologies are at pilot-ready stage but with some early research and development needs
- Some shared learning between power and industrial sectors but with some unique challenges and technologies required too.
- Cost estimates highly uncertain for most industries (for most expensive 30-330£/tCO_2)
- Costs also highly variable depending on heat source

Next steps

- What does this tell us about the next step towards deployment?
  - Is more R+D needed?
  - How can costs be made more certain?
  - MACC curves assume all uptake by 2030 which is unrealistic – how to phase?
  - At what point does CCS become affordable – impact of carbon price but also competitiveness?
  - What other market failures are there?
  - Can we encourage more cooperation?

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Any Questions

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