Grid-scale electricity storage
using an innovative form of
Compressed Air Energy Storage

Consultation on Carbon Capture, Usage and Storage

Input to BEIS consultation July 2019

Issues with CCUS

Carbon Capture, Usage and Storage has a number of major issues that need to be addressed before it will become commercially viable, including:

1. Capital cost;
2. Plant operational cost including efficiency;
3. Insurance risk;
4. Usage;
5. BECCS.

This information will then be applied to considerations of:

6. CCS for electricity generation,
7. CCS for hydrogen creation, and
8. CCS for industry.

From this, conclusions can be drawn on the proper potential for CCUS to support the industrial and power generation sectors, behind which the government's strategy should be structured.

Capital cost

The capital cost of CCUS is immense, increasing a gas-fired power station by 83-280%[1]. Even assuming that the (very expensive) offshore pipe and injection (into depleted hydrocarbon wells) infrastructure exists, there needs to be major capital expenditure on the plants, and on the pipes (est. ~£1m/km) to connect them to the offshore pipes.

For this reason, all the dozens of proposed American CCS generation projects have been cancelled prior to construction[2]. If they can't afford it, how can the UK? But see the proposed strategy, below.

Plant operational cost including efficiency

CCS imposes a 12-39%[3] reduction in efficiency on the plant to which it's added. This is an enormous reduction which increases its operational cost (LCOE) by 31-119%[4].

Equinor (formerly Statoil) currently do CCS with oil recovery, extracting the CO2 on the offshore platform where the oil is extracted and where the CO2 is also re-injected

[1] See table2 p5 of https://core.ac.uk/download/pdf/81168054.pdf (Performance and Costs of CO2 Capture at Gas Fired Power Plants, Neil Smit et alia, Energy Procedia 37 (2013) 2443 – 2452) referring to this report as "Perf&Cost"
[2] E.g. https://en.wikipedia.org/wiki/Kemper_Project and https://www.smithsonianmag.com/smart-news/major-clean-coal-project-mississippi-shut-down-180963898/
[3] See table1 p4 of Perf&Cost
[4] See table2 p5 of Perf&Cost

(thereby eliminating transport costs and taking advantage of higher, hence cheaper per volume] concentrations of CO2, and adding benefits of enhanced oil recovery (EOR). Despite this, they say that CCS is only remunerative with a carbon price well above $60/tonne[5], a price not envisaged in UK or EU policy.

Insurance risk

CO2 is heavier than air. Therefore if there is a leakage, whether from pipes or from the injection reservoir, it will hover over the land or sea asphyxiating anyone within the CO2 cloud until it is dispersed by the wind. Pipeline risks are manageable and insurable, only existing for as long as the pipes are in use; the geological risk is neither manageable nor insurable, and will remain for millions of years until the tectonic plate is subducted[6]. Business rightly says that they cannot stand such risk, and that governments will have to do so[7]. However the 6 governments with North Sea coasts asked the EU to bear that risk, following which it issued the EU Directive on the Geological Storage of Carbon Dioxide ('CCS Directive') (Directive 2009/31/EC) which has too many ongoing liabilities and complex / ill-defined technical requirements for any company to rely upon[8]. Unless this insurance risk is dealt with definitively, CCS can never succeed. Nearly every report into CCS ignores this insurance risk.

Moreover, only a proportion of CO2 is captured, with costs rising exponentially with percentage captured[9]. This means that a percentage (typically assumed to be 20%, to keep CCS costs below the realms of the fantastical) of emissions remain. As there are harder-to-decarbonise sectors than electricity, a target of 20% emissions for the country requires zero net emissions from the electricity industry[10].

Usage

Usage is at a very early stage of development, with some promising lines of development – however these are all at very early (mostly theoretical and laboratory) stages. And most of them result in the re-emission of the CO2 later on. The UK parliament has released a briefing on this[11]. Therefore usage does not carry promise

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[5] Public written statement: https://www.equinor.com/en/magazine/carbon-pricing.html. The $60/tonne figure was given verbally in a conference presentation at which the author was present. The project is reported https://www.ice.org.uk/knowledge-and-resources/case-studies/sleipner-carbon-capture-storage-project - saying "CCS in the medium term … will require a strong public-private-partnership structure where Governments take the role as a 'value chain integrator' and guarantor as well as tailor financial support to complement the current low CO2 price.", where the "current low CO2 price" is reported in the same article as $60/tonne.

[6] https://www.sciencedirect.com/science/article/pii/S1876610213006280

[7] https://www.businessgreen.com/bg/news/2226389/insurers-warn-governments-will-have-to-share-ccs-risks and http://www.sccs.org.uk/news/509-sccs-statement-the-future-of-the-oil-gas-industry

[8] https://www.ucl.ac.uk/cclp/ccsliable.php

[9] https://www.treehugger.com/corporate-responsibility/carbon-capture-and-storage-will-happen-heres-why-we-should-support-it.html

[10] https://www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming/, which also says that a target of net zero national emissions requires substantial NEGATIVE emissions by the electricity industry.

[11] https://researchbriefings.parliament.uk/ResearchBriefing/Summary/POST-PB-0030 ("CCC Report")

of major CO2 emissions reduction in the near future, so the principal target for national emissions reduction must remain CCS.

BECCS

BECCS (bioenergy with carbon capture and storage) is identified by many (including the CCC Report) as almost the only technology that can, in the near future, yield the negative emissions required to stabilise the earth's climate. However it has a number of limitations, not least:

1. There is insufficient land to grow crops or trees for bioenergy, because that land is needed for agriculture;
2. Waste biomass is nowhere near plentiful enough to provide a substantial proportion of world or national generation needs – and would reduce the amount available for composting;
3. Bioenergy emissions figures almost invariably ignore the emissions relating to planting, managing, harvesting, treating (usually pelletising and drying) and transporting the biomass.

CCS for Electricity Generation

CCS is not needed to decarbonise electricity generation: this can be achieved by nuclear and/or renewable generation plus large-scale long-duration zero-carbon storage. In the medium term this is also likely to include the development of a substantial hydrogen sector in the economy to replace a significant part of today's gas sector and to power fuel cells in vehicles and elsewhere.

However CCS is needed for negative emissions, in connection with BECCS power stations.

CCS for Hydrogen Creation

The cheapest way to form hydrogen is (by a factor of roughly three) by re-forming methane, principally using SMR (Steam Methane Reformation). However in a zero-carbon energy system, it requires CCS plus negative-emissions BECCS to balance out residual emissions from the 80% capture rate of CO2, and from methane leakage in the system. If a proper price were put on emissions, this would be prohibitively expensive, especially given the capital and operational costs of CCS and its insurance risks.

Electrical ways of forming hydrogen from water are being developed, and their costs are coming down. These can be truly zero-emission systems if the electricity derives from zero-carbon sources. The main issue is with scale-up: PEM (Proton Exchange Membrane) suffers the same problems as batteries for grid support: very expensive at large scale, and with a short life before key parts (in this case, mainly the membrane) needs renewing. There are however a number of other technologies that show promise of large-scale hydrogen production at cheap cost, provided their development and pilot plants are supported from public funds.

CCS for Industry

There are and will always remain some industrial and chemical processes that cannot avoid emissions. Therefore industrial CCS will be needed. But due to its cost, it will only be affordable in clusters[12] – of which the British government has identified 5 – Humber, Merseyside, Teesside, Runcorn and Grangemouth[13].

Conclusions
CCS for electricity generation is only necessary in terms of a limited amount of BECCS, to yield negative emissions. All other electricity generation CCS is unnecessary and excessively costly; there are cheaper and more practical alternatives available today.

CCS for hydrogen production is also unnecessary and, if emissions is priced correctly, excessively costly. The cost of non-methane hydrogen generation is falling rapidly, and practical large-scale technologies are in development.

CCS for industry will remain, but only within major industrial clusters owing to its cost and complexity.

Proposed Strategy
Develop industrial CCS.

Develop BECCS, to piggy-back on industrial CCS locations – anywhere else is too expensive.

Mitigate insurance risks by declaring a no-ship marine park over every CCS storage site; any shops venturing there do so at their own risk. This will incidentally help the fishing industry too.

Focus government time, money and efforts on renewable and zero-carbon electricity generation, large-scale long-duration electricity storage, and large-scale methane-free hydrogen production.

12 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/759637/beis-ccus-action-plan.pdf

13 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/759286/BEIS_CCS_business_models.pdf

Grid-scale electricity storage
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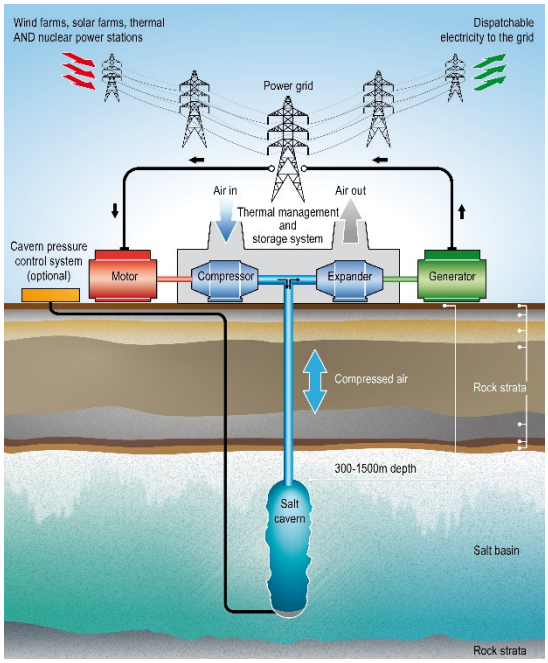
About Storelectric

Storelectric (www.storelectric.com) is developing transmission and distribution grid-scale energy storage.

- Innovative adiabatic Compressed Air Energy Storage (TES CAES). Our 500MW, 2.5-21GWh installations have zero/low emissions, operate at 68-70% round trip efficiency, levelised cost significantly below that of gas-fired peaking plants, and use existing, off-the-shelf equipment.
- Their CCGT CAES technology converts and gives new economic life to gas-fired power stations, halving emissions and adding storage revenues. Addresses the entire energy trilemma: the world's most cost-effective and widely implementable large scale energy storage technology, turning locally generated renewable energy into dispatchable electricity.



The potential to store the entire continent's energy requirements for over a week; potential globally is greater still. In the future, Storelectric will further develop both these and hybrid technologies, and other geologies for CAES.

About the Author

Mark Howitt is Chief Technical Officer, a founding director of Storelectric. He leads Storelectric's technical and operations, minimising technological risk, maximising efficiency and environmental friendliness, and speed to market. He focuses on technologically simple solutions using proven technologies wherever possible.

His degree was in Physics with Electronics. He has 12 years' management and innovation consultancy experience world-wide. In a rail multinational, Mark developed 3 profitable and successful businesses: in commercialising a non-destructive technology he had innovated, in logistics and in equipment overhaul. In electronics manufacturing, he developed and introduced to the markets 5 product ranges and helped 2 businesses grow strategically.