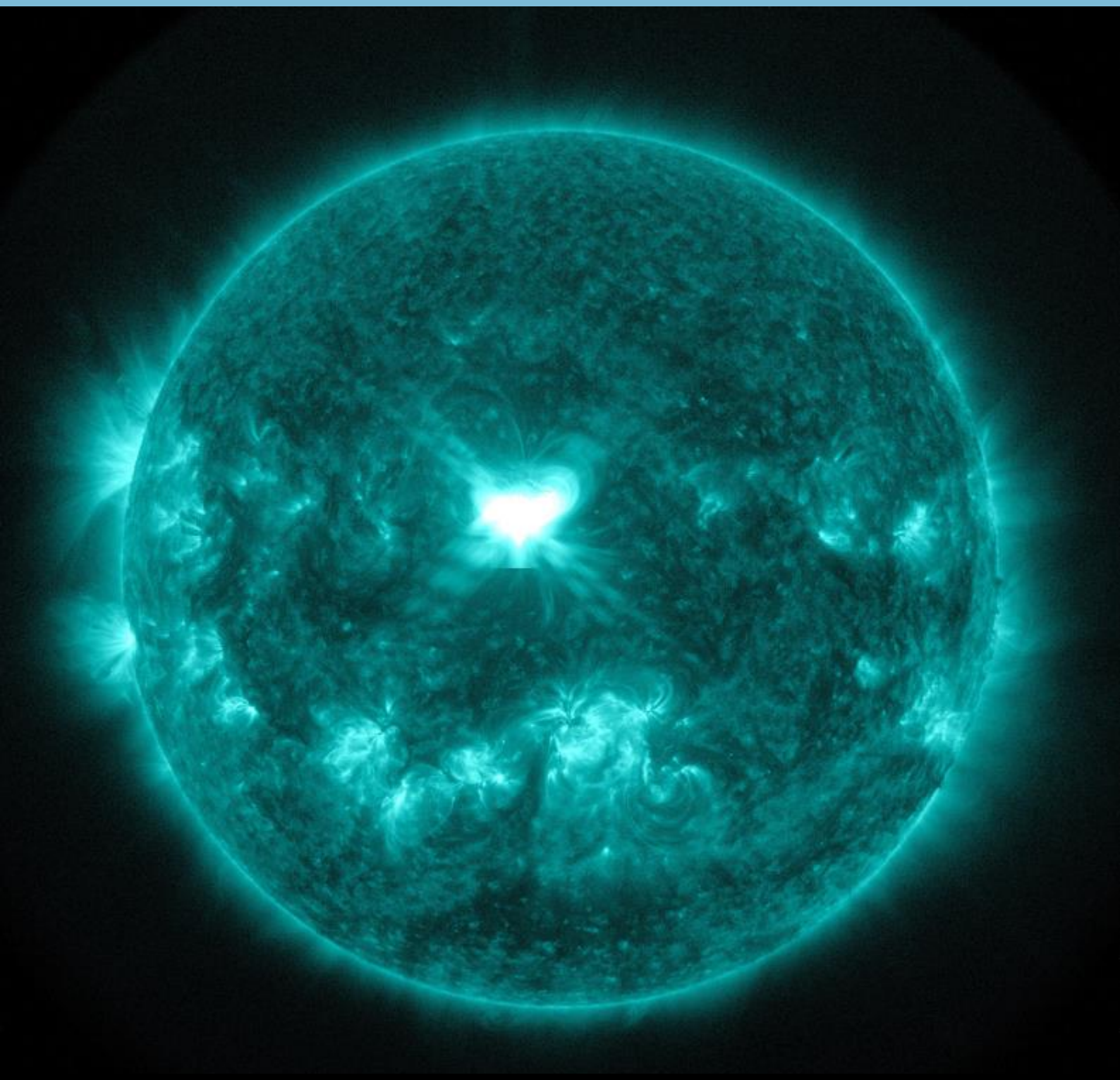
Starting a hydrogen economy on the east coast

Response to the National Infrastructure Commission call for evidence

March **2017**



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Sandbag's vision for 2018:
To create a hydrogen supply hub on the east coast of England.
This allows for innovation in new hydrogen technologies, an upgrade of UK infrastructure, creates export opportunities, and leads to full decarbonisation of the gas heat network.

Step 1: Creating a hydrogen supply hub at one of the east coast UK gas terminals in 2018.

Hydrogen is straightforward to produce and is already widely synthesised for industrial applications.[1] Steam methane reforming plants have been used for decades to convert natural gas into hydrogen and CO_2. They can be bought off-the-shelf, and deployed rapidly and at scale. Waste CO_2 from the SMR process can easily be captured and injected into offshore fields via existing subsea gas pipeline infrastructure.

To effectively decarbonise heat, the UK needs a hydrogen supply at one of England's four east coast gas terminals by 2018. The main gas terminals in England are at Teeside, Easington, Theddlethorpe and Bacton (plus St Fergus in Scotland, but this location lacks the same concentration of industry). Steam Methane Reform facilities should be installed before 2020, with a small capacity, but able to quickly scale up.

CO_2 produced from Steam Methane Reform can immediately be stored. Initially, the hydrogen capacity would be quite small, so the CO_2 waste would be similarly small. The CO_2 could be initially delivered via ship to Norway for storage, a process that Gassnova and Statoil have begun scoping domestically and for North Sea ports.[2] It is also possible that oil and gas companies would be keen to use CO_2 as injection to enhance oil and gas production.[3] As the volumes of hydrogen production, and therefore waste CO_2, increase, there is potential to use old gas lines to inject CO_2 into old gas fields, which is already being considered as North Sea decommissioning proceeds.[4]

Hydrogen would initially serve an industrial cluster with any excess being blended into the gas grid. Existing gas pipeline infrastructure is capable of blending up to 20% of hydrogen content (a pilot scheme named HyDeploy has begun to test this at Keele University).[5] Injecting even a small amount of hydrogen reduces the CO_2 footprint of heating a home and will kick-start the process of repurposing the natural gas grid for hydrogen. To date, there has been no clear policy strategy for reducing CO_2 from gas heating systems. Partially injecting hydrogen to the natural gas stream could be a useful bridge at the same time as insulation in homes across the UK is improved to increase efficiency.

How much would this cost? The proposal is low-cost as it requires minimal additional storage or pipelines – the most expensive part of hydrogen economy – to be built in the initial phase. It also means the hydrogen could be

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[1] *EU production was approximately 4,000 tonnes per day in 2015* http://hydrogen.pnl.gov/hydrogen-data/hydrogen-production
[2] *Norway Examines Feasibility of CO_2 Shipping (2017) The Maritime Executive* http://www.maritime-executive.com/article/norway-examines-feasibility-of-co2-shipping
[3] *The Scottish CCS research group discuss the potential of using CO_2 for North Sea enhanced oil recovery in this report (2015)* https://www.hw.ac.uk/about/news/enhancing-north-sea-oil-recovery-can-store.htm
[4] *Brent field decommissioning programmes (2017) Shell UK* https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/590212/Brent_Field_DP.pdf
[5] *HyDeploy (2016) National Grid* http://media.nationalgrid.com/press-releases/uk-press-releases/east/boost-for-low-carbon-future-as-national-grid-scoops-11-million-for-ground-breaking-test-projects/

converted continuously and high utilisation will ensure that unit costs remain low. In the US, the National Renewables Energy Lab has priced the costs of hydrogen, converted using steam reformation from natural gas[6]

[6] *Hydrogen station cost estimates (2013) NREL www.nrel.gov/docs/fy13osti/56412.pdf*

Step 2: Unleashing innovation for new hydrogen technologies, upgrading UK infrastructure and creating new export opportunities

A hydrogen hub will enable innovation in hydrogen technologies with low-risk. There are many project proposals to decarbonise a variety of sectors using hydrogen – for example the plan to convert Leeds gas network to run on hydrogen.[7] If there is a ready supply of zero-carbon hydrogen already in place, this and other projects will become much cheaper and of lower risk – they can simply tap into the hydrogen already flowing. The flexibility is provided because hydrogen can be injected into the gas grid up to 20% of the mix, or used in other projects.

A use for surplus renewable electricity. Knowing there are high value uses of hydrogen, means that surplus renewable electricity can be more easily deployed for electrolysis to create hydrogen, rather than paying for renewable curtailment.

Hydrogen can be used as an energy input across the economy: for heating, electricity, transport and industry. What is more, the infrastructure for these different inputs often overlaps. Below we analyse opportunities in each of these sectors in turn:

HEATING:

The biggest opportunity for hydrogen in the UK economy is to reduce CO_2 in the heating sector. The Leeds project to convert the whole of Leeds to hydrogen is a high risk project owing to it being the first of its kind. Through rapid deployment of hydrogen hubs on the east coast, smaller local projects to convert to hydrogen could be implemented very quickly and cheaply.

ELECTRICITY:

There is potential for hydrogen fuel cells to contribute to baseload electricity generation, which is currently supplied by nuclear, coal and gas power plants. The cost development of hydrogen fuel cells is analogous to that of lithium batteries which have been driven by trends in global car manufacturing. These include Toyota / Lexus[8], GM / Honda[9], BMW[10], and Mercedes[11], with large research budgets already translating into actual production cars on the market.

As the costs of hydrogen fuel cells decline, they may soon be favoured as low cost capacity over gas CCGT power plants. Estimates produced by the UK Government indicate CCGT power plants cost in the region of £400-600/KW.[12] However, the US Government's forecast for hydrogen fuel cell prices is $53/KW if deployed at scale[13] – just a tenth the price of a CCGT power plant.

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[7] *Leeds City Gate H21 programme* http://www.northerngasnetworks.co.uk/archives/document/h21-leeds-city-gate

[8] *Toyota Hydrogen Fuel Cells* http://www.toyota-global.com/innovation/environmental_technology/fuelcell_vehicle/

[9] *GM Teams Up With Honda To Manufacture Fuel Cells Near Detroit (Jan 2017) Forbes* www.forbes.com/sites/samabuelsamid/2017/01/30/gm-and-honda-form-joint-venture-to-manufacture-fuel-cells-near-detroit

[10] *Hydrogen fuel cell only makes sense above the 5 series (Jan 2017) BMW blog* http://www.bmwblog.com/2017/01/27/bmw-fuel-cell-makes-sense-5-series/

[11] Mercedes-Benz GLC plug-in hydrogen fuel-cell coming in 2017 *(June 2016) Autoblog* http://www.autoblog.com/2016/06/13/mercedes-benz-glc-plug-in-hydrogen-fuel-cell-coming-in-2017/

[12] *Coal and gas assumptions (March 2014) DECC* https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/315717/coal_and_gas_assumptions.PDF

[13] DOE Hydrogen and Fuel Cells Program Record(September 2016) US Department of Energy https://www.hydrogen.energy.gov/pdfs/16020_fuel_cell_system_cost_2016.pdf

The fuel cells can be deployed centralised or decentralised on customer's sites, and can even reuse the waste heat, for example in a Radisson Hotel project with E.ON[14].

Furthermore, decommissioned power plants that are situated close to gas terminals where the hydrogen can be synthesised provide suitable sites for housing large arrays of fuel cells:

- TEESSIDE is connected to a 2GW decommissioned CCGT is already[15]
- EASINGTON is within 66 miles to 3 decommissioning large coal power plants, which could host new power plants (54 miles from Drax, 61 miles to Eggborough, 66 miles to Ferrybridge), and 10 miles to Killingholme gas power station.
- THEDDLETHORPE is within 58 miles to 2 two large decommissioning coal power plants (58 miles to Cottam, 55 miles to West Burton).

TRANSPORT

As mentioned above, R&D in the car manufacturing sector has, in a short space of time, led to hydrogen vehicles coming to the market. One of the greatest barriers to adoption of hydrogen vehicles is the lack of refuelling infrastructure. Volkswagen has suggested Japan is the only country currently committed to developing that infrastructure and hydrogen cars will therefore struggle outside of Japan[16].

Building initial infrastructure on the east coast means refilling infrastructure could be rolled out on a region-by-region basis as appropriate, without needing a large-scale risky commitment.

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[14] *Low emission hotel in Frankfurt (2017) E.On http://www.eon.com/en/media/news/press-releases/2017/2/8/radisson-blu-and-eon-form-partnership-for-a-low-emission-hotel-in-frankfurt.html*

[15] *Teesside Power Station to be demolished, owner GDF SUEZ confirms (October 2013) GazetteLive http://www.gazettelive.co.uk/business/business-news/teesside-power-station-demolished-owner-6138248*

[16] *Volkswagen: Hydrogen Fuel Cell Cars Hopeless Outside Of Japan (September 2014) Cleantechnica https://cleantechnica.com/2014/09/15/volkswagen-hydrogen-fuel-cell-cars-hopeless-outside-japan/*