# Scottish Energy Strategy – Consultation Response

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SCCS

# Scottish Energy Strategy – Consultation Response

## SCCS response to the Scottish Government consultation on the draft Scottish Energy Strategy

May 2017

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# Scottish Energy Strategy – Consultation Response

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Scottish Carbon Capture & Storage (SCCS) is a research partnership of the British Geological Survey, Heriot-Watt University, University of Aberdeen, the University of Edinburgh and the University of Strathclyde. SCCS researchers are engaged in innovative applied research and joint projects with industry and government to support the development and commercialisation of carbon capture and storage (CCS) as a climate change mitigation technology.

## 1 Context and introduction

Scotland has achieved great progress in decarbonising its energy system since 1990, largely by means of closure of historic industries and installation of renewable electricity generation. To decarbonise further requires more than just more renewable energy; a low-carbon approach for all energy is needed, not just for electricity. Deployment of CCS is essential to achieving deep decarbonisation of the Scottish economy. CCS is a suite of technologies for directly and substantially reducing carbon dioxide ($CO_2$) emissions resulting from the use of carbon-containing fuels, including biomass and fossil hydrocarbons. Scotland is uniquely placed to develop, demonstrate and deploy CCS through its combination of excellent resources and applicable industries and skills.

SCCS welcomes the Scottish Government's increased recognition of the importance of CCS and their corresponding support for its development and deployment.

The abrupt cancellation of the UK Department of Energy and Climate Change (DECC) CCS commercialisation programme in the November 2015 UK Autumn Statement was a major setback. The decision appears to have been taken from a narrow and short-term fiscal perspective that overlooked the technical capability of the Peterhead CCS demonstration project, the potential for North Sea subsurface sector re-deployment and the wider strategic necessity of CCS to achieve least-cost decarbonisation.[1,2] The UK Department for Business, Energy and Industrial Strategy (BEIS) now retains a "strategic interest" in CCS, but there is little evidence of willingness for concerted near-term action by BEIS aligned with the CCS objectives and timelines presented in the 2017 draft Scottish Climate Change Plan. It is plausible that the forthcoming UK election may result in a new Cabinet, Secretary of State and Ministers for Energy in June 2017; this is likely to delay strategic planning in the UK to at

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[1] Carbon Capture and Storage Association. (2016). *Lessons Learned – Lessons and Evidence Derived from UK CCS Programmes 2008-2015.* http://www.ccsassociation.org/index.php/download_file/view/1023/503/

[2] UK Climate Change Committee. (2016). *Letter to Rt Hon Amber Rudd: A strategic approach to Carbon Capture and Storage.* https://www.theccc.org.uk/publication/letter-to-rt-hon-amber-rudd-a-strategic-approach-to-carbon-capture-and-storage/

least 2018. As a result, Scotland may need to consider how to progress its agenda through devolved investment and powers.

Internationally, CCS has largely failed to advance beyond a handful of large demonstration projects in electricity generation. This suggests that the CCS development model of large power plant "anchor projects", building large-scale $CO_2$ transport and storage infrastructures to facilitate subsequent clustering, is overly complex and risky to deliver, especially in an electricity sector undergoing rapid and radical transformation.

Instead, SCCS advocates that Scotland adopts a phased approach to CCS, targeting small-scale $CO_2$ capture opportunities across diverse sectors and with much lower capital costs. In parallel, Scotland should act rapidly to ensure the strategic retention of existing hydrocarbon pipelines suitable for future conversion to $CO_2$ use. Further detail can be found in our December 2016 submission on the development of the Scottish Energy Strategy.[3]

The following sections detail our responses to the consultation questions relating to CCS (Questions 1, 2, 3, 4, 6 and 7).

## 2 Question 1: *What are your views on the priorities presented in Chapter 3 for energy supply over the coming decades? In answering, please consider whether the priorities are the right ones for delivering our vision.*

The five proposed priorities for energy supply (supporting North Sea hydrocarbon production; supporting demonstration of CCS; exploring the role of new energy sources; increasing renewable energy generation; and increasing flexibility, efficiency and resilience of the energy system) present a generally balanced coverage of areas of focus for Scotland's near and longer-term future energy supply, aligned with the 2050 vision and Scotland's energy resources and potentials. In particular **we strongly welcome the prioritisation of CCS commercialisation as an essential component of Scotland's energy system decarbonisation.**

We address specific details on the proposed actions relating to the priorities on oil and gas, CCS, bioenergy and new energy vectors (hydrogen) in answer to Questions 2, 4 and 7 below. We support the need to maintain a flexible approach to energy transition and decarbonisation to accommodate the substantial uncertainties and unknowns of technological and market changes (paragraph 65). However, we strongly advocate that this **uncertainty should not deter Scottish Government from acting now to create and investigate options for the future**, which can inform strategic energy supply opportunities and needs.

Here, the case for CCS support is compelling. The TIMES modelling undertaken by Scottish Government shows the interconnections between different parts of the energy system and

[3] Scottish Carbon Capture & Storage. (2016). *Scotland's Energy Strategy: The role of carbon dioxide capture and permanent storage.* http://www.sccs.org.uk/images/expertise/reports/working-papers/WP_SCCS_2016_07_Scotland_Energy_Strategy_2.pdf

larger economy. Consequently, CCS is clearly not a "standalone priority". **Prioritisation of CCS demonstration and commercialisation should reflect its cross-sectorial importance to delivery of the other energy priorities** both in the near-term and in delivering a coherent pathway towards achieving the 2050 vision.

We welcome the linkage made in the CCS section (paragraph 90) to the potential for re-use of oil and gas infrastructures to reduce entry costs and development risks. We are, however, surprised that the only explicit mention of CCS in the section on supporting the recovery and future of the North Sea oil and gas sector is with reference to the Oil and Gas Climate Initiative fund (box-out, page 33). **We suggest that the potential for CCS to support the sustainability and transition of Scotland's oil and gas sector should be explicitly recognised**, (for example, in paragraph 74). CCS is strongly aligned to the sector's existing assets and skills, and is a potential profit-making opportunity. Analyses by SCCS and industry partners have shown the substantial potential for $CO_2$ enhanced oil recovery to maximise economic recovery, to add new reserves, to extend the operations of existing fields, to rapidly reduce the carbon intensity of produced hydrocarbons, and to accelerate the commercialisation of CCS.[4] If properly encouraged and supported, **$CO_2$ storage offshore, beneath the North Sea and globally, and $CO_2$ enhanced oil recovery have the potential to become Scottish industries comparable in scale to the offshore hydrocarbon industry today**.

Similarly, in the section on exploring new energy sources, CCS to enable low-carbon production of bulk hydrogen from methane is noted in the box-out on "Hydrogen as a means to decarbonise heat" (page 36), but hydrogen is not explicitly mentioned in the priority on CCS (paragraph 87 refers only to "decarbonisation of heat"). We note the better linkage between the priority on renewables (bioenergy opportunity box-out, page 43), with the action on bioenergy in combination with CCS (page 37).

The provision of hydrogen for heating can also enable the supply of hydrogen for transport, especially for heavy vehicles, which have limited low-carbon options. The entry costs and deployment risks for hydrogen as an energy vector supplying both heat and transport can be reduced by such interconnection, a factor that we understand the TIMES model does not as yet recognise.

The priority on flexibility, efficiency and resilience notes the importance of thermal power generation (paragraphs 142 and 143) to provide system resilience but does not explicitly mention that this will very likely require CCS to be compatible with the vision for "almost complete decarbonisation of the energy system" (page 30).

Lastly, as identified in Scotland's draft Climate Change Plan,[5] the ability to achieve some "negative carbon emissions" is important in the strategy to reduce emissions in Scotland to

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[4] Scottish Carbon Capture & Storage. (2015). *$CO_2$ storage and EOR in the North Sea: Securing a low-carbon future for the UK.* http://www.sccs.org.uk/images/expertise/reports/co2-eor-jip/SCCS-CO2-EOR-JIP-Report-SUMMARY.pdf

[5] Scottish Government. (2017). *DRAFT CLIMATE CHANGE PLAN. The draft third report on policies and proposals 2017-2032*. http://www.gov.scot/Resource/0051/00513102.pdf

very low levels overall. Achieving some “negative emissions” is likely to cost less than total elimination of all greenhouse gas sources, but with the same net effect. “Negative carbon emissions” can be achieved through a combination of increased afforestation and sustainable bioenergy combined with CCS. Capture of $CO_2$ from biological processes, such as fermentation or directly from the air may also have a role when combined with permanent $CO_2$ storage. To understand and enable these "negative emission" approaches through the energy system, improved TIMES modelling and the resulting policy connections between energy and land use should be developed and applied.

## 3 Question 2: *What are your views on the actions for Scottish Government set out in Chapter 3 regarding energy supply? In answering, please consider whether the actions are both necessary and sufficient for delivering our vision.*

Overall, we welcome the actions outlined for the priority areas and the clear recognition of the importance of CCS.

With respect to the suggested actions on CCS (page 37), we have concern that these are insufficient to secure delivery of the vision objective for “carbon capture and storage… operational at large-scale” underpinning “almost complete decarbonisation of the energy system” (page 30). Here, **we urge greater clarity on the specific nature of Scottish Government support for CCS.** For example, indicative timelines for the operation of small-scale projects (Action 1, page 37) would give clear signals to industry and investors. Similarly, bioenergy and CCS (Action 2, page 37) operates from 2027 in the Scottish Government’s draft Climate Change Plan (page 38 of Plan).[6] **Delivery of bioenergy with CCS within a decade is possible but requires much greater detail of the support and investment programme in Scotland** than the presented action to “explore the opportunity” (page 37).

With respect to Actions 3 and 4 (page 37), beyond general statements of “retaining strategic interest”, the UK Government has made no public commitment to CCS since the 2015 cancellation of the DECC commercialisation programme. CCS is entirely absent from the recent BEIS green paper on “Building our Industrial Strategy”,[7] is barely present in the UK’s current energy and emissions projections (“carbon capture and storage is not assumed to come on in any significant capacity over the period of this modelling”),[8] and remains an unknown in the repeatedly delayed and overdue UK Clean Growth Plan (also referred to as the UK Emissions Reduction Plan). As such, we suggest that reliance on UK Government support for near-term CCS delivery is a substantial risk. **Scottish Government should**

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6 Scottish Government. (2017). *DRAFT CLIMATE CHANGE PLAN. The draft third report on policies and proposals 2017-2032*. http://www.gov.scot/Resource/0051/00513102.pdf

7 Department for Business, Energy & Industrial Strategy. (2017). *Building our Industrial Strategy: green paper*. https://www.gov.uk/government/consultations/building-our-industrial-strategy

8 Department for Business, Energy & Industrial Strategy. (2017). *Updated energy and emissions projections 2016*. https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2016

**consider presenting a "Plan B" approach, taking advantage of ready-to-go CCS opportunities in Scotland.**

Near-term developments under a Scotland-directed CCS Plan B should include a mix of enabling low-cost $CO_2$ transport and storage infrastructure development and small-scale $CO_2$ capture pilot projects. First and foremost, the Acorn CCS Project,[9] which has recently been awarded design funding from the EU European Research Area "Accelerating CCS Technologies" research and innovation programme,[10] plans a minimum viable demonstration of fully integrated CCS in the early 2020s. It will involve use of existing $CO_2$ capture facilities at St Fergus and re-purposing of an existing pipeline to transport $CO_2$ to offshore storage. Alongside, the piloting of small-scale capture of high-concentration $CO_2$ releases from, for instance, distilling, brewing and biomethane production could begin now.

For Action 5 (page 37), retaining critical legacy oil and gas infrastructure, we welcome the strong attention Scottish Government and Ministers have given to this matter to date and support its inclusion as a priority action for ongoing attention. Any **premature decommissioning of pipelines and boreholes would be a substantial setback for CCS development in Scotland** and would incur significant delays and cost increases. In particular, the Acorn Project is strategically designed around progressive re-use of legacy pipelines to enable flexible expansion of $CO_2$ storage provision to meet future demand. Here, we also note the importance of onshore pipeline infrastructure, in particular the uniquely positioned No.10 Feeder gas pipeline, which has been assessed as suitable for $CO_2$ transport and can be made available to link opportunities for $CO_2$ capture on existing or new facilities in the Central Belt to $CO_2$ storage sites under the North Sea.[11]

With respect to the actions for the other priority areas, the following paragraphs build on our answer to Question 1 above.

Firstly, we note the absence of CCS in the actions relating to oil and gas sector support (page 33). We highlight **the huge potential for CCS to provide long-term sustainable transition for the oil and gas sector, directly applying its infrastructure and its knowledge and skills in fluid handling and the subsurface** (Actions 2 and 3). Again, we emphasise the potential[12] for $CO_2$ enhanced oil recovery to maximise recovery (Action 1), and the potential for CCS expertise to be applied globally (Action 4).

For actions relating to new energy sources (page 36), we **welcome the prioritisation of examining hydrogen as a zero-carbon energy vector, and the recognition of the**

9 Pale Blue Dot. (2017). *Acorn CCS Project*. https://pale-blu.com/acorn/

10 Scottish Carbon Capture & Storage. (2017). *Acorn project wins EU funding to progress CCS in UK.* http://sccs.org.uk/news/393-acorn-project-wins-eu-funding-to-progress-ccs-in-uk

11 Peter A. Brownsort, Vivian Scott, R. Stuart Haszeldine. (2016) Reducing costs of carbon capture and storage by shared reuse of existing pipeline – Case study of a $CO_2$ capture cluster for industry and power in Scotland. *International Journal of Greenhouse Gas Control*. **52**: 130-138. (Full paper available on request from peter.brownsort@ed.ac.uk).

12 Scottish Carbon Capture & Storage. (2015). *$CO_2$ storage and EOR in the North Sea: Securing a low-carbon future for the UK.* http://www.sccs.org.uk/images/expertise/reports/co2-eor-jip/SCCS-CO2-EOR-JIP-Report-SUMMARY.pdf

**importance of CCS in near- to mid-term bulk hydrogen delivery at competitive cost** (see Question 7 below). We also note (above) the hydrogen interaction with options for decarbonising transport. However, we note that hydrogen is not explicitly mentioned in the actions for supporting CCS (page 37) and suggest that this key interdependency be given clearer prominence. For renewables actions and energy and system resilience actions, we similarly suggest that the actions referring to the Bioenergy Action Plan (page 47) and re-powering electricity generating sites (page 51) note the linkage with CCS.

On bioenergy, we welcome the recognition of combining biomethane-fuelled electricity generation with CCS to give the potential for negative emissions (page 43). We suggest that **there are further opportunities for negative emissions from bioenergy combined with CCS**. However, these opportunities need to be considered individually as each has different merits and challenges, as outlined below.

Biomethane from anaerobic digestion, or equally methane recovered in landfill gas, contains a significant proportion of $CO_2$ (often around 50%) and is used in two principal ways. It is either used "whole" by combustion for electricity generation (or more usually and preferentially for combined heat and power), which is the use suggested in the draft Energy Strategy for combination with CCS. Alternatively, biomethane may be upgraded to pipeline quality and injected to the gas grid. Upgrading is by separation of impurities, including the $CO_2$, which is usually vented. This $CO_2$ stream is concentrated and can be captured for storage, or for utilisation. We suggest that the Energy Strategy should note both these opportunities and promote the combination of biomethane production with CCS while recognising that feedstocks for anaerobic digestion are limited and policy should not encourage the production of additional waste as feedstock.

Separately, biomass combustion can be combined with CCS leading to "negative" $CO_2$ emissions. Most biomass combustion units are small and provide an effective source of renewable heat with "neutral" $CO_2$ emissions, predominantly in rural areas where other options for low-carbon heat may be limited. However, the bulk of $CO_2$ emissions from biomass combustion in Scotland comes from a small number of large units, mostly combined heat and power plants. Emissions from these units are considered "neutral" but, if biomass combustion is combined with CCS, it can result in effectively negative emissions. One challenge to this suggestion is the sustainability of large-scale biomass supplies for combustion; another is the location of some of the larger existing plants, distant from potential $CO_2$ transport and storage infrastructure. We suggest the Energy Strategy should recognise this opportunity for negative emissions from biomass combustion combined with CCS and support appropriate developments while exercising caution to ensure sustainability and best use of biomass supplies.

For all these possible combinations of bioenergy with CCS to give negative emissions, the scale of operation is likely to be small or, at best, medium compared to fossil fuel-based CCS projects, such as proposed for industry or thermal generation. This need not be a technical barrier; there are existing, commercially operating technologies available for $CO_2$ capture and transport at smaller scales. However, to count as negative emissions, there is clearly a need for permanent storage of $CO_2$ on a bulk scale to be developed. We believe Scottish

Government should pursue a "twin track" approach as previously set out,[13] encouraging work on smaller scale CCS projects, such as on bioenergy, while taking necessary actions to secure the development of permanent geological $CO_2$ storage.

## 4 Question 3: *What are your views on the proposed target to supply the equivalent of 50% of all Scotland's energy consumption from renewable sources by 2030? In answering please consider the ambition and feasibility of such a target.*

As the UK Government reserves significant powers on energy market designs, any overarching Scottish energy mix targets will necessarily be aspirational, to some extent, and seeking suasion of UK policies (and, subject to the terms of Brexit, EU policies). This is not, however, to dismiss their importance as a signal of ambition and intent to the public and investors, and as a framework for the coordination of focused government policies at national and local levels. In this context, a target of 50% of energy consumption from renewable sources by 2030 presents an option for a simple, ambitious, but, arguably, technically achievable target.

However, we have a number of observations on this target outlined in the following sections.

### More renewables and less carbon:

Renewable energy technologies have made substantial contributions to reducing energy related emissions and will continue to do so. However, a sole focus on "renewables for renewables' sake", which a renewable energy share target might encourage, may not be the quickest and/or most cost-effective approach to the primary objective of economy-wide decarbonisation. Here, we suggest that the **primacy of the final and interim decarbonisation targets should remain clear and that technology targets should be seen as complementary and supportive** rather than as standalone objectives.

### Feasibility and cost:

Renewable energy technologies have made remarkable cost reductions over the last decade and costs are projected to continue to decrease. However, the feasibility and cost of a majority renewable system based predominantly on variable generation (wind) is largely unknown, especially in a high-latitude location with substantial seasonal variation in energy demand for heat.

Only three advanced economies currently meet half or more of their final energy demand from renewables: Iceland c. 77%, Norway c. 70%, and Sweden c. 50%.[14] In Iceland this is from immense geothermal resources and abundant hydropower; in Norway, this is the result of

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[13] Scottish Carbon Capture & Storage. (2016). *Scotland's Energy Strategy: The role of carbon dioxide capture and permanent storage.* http://www.sccs.org.uk/images/expertise/reports/working-papers/WP_SCCS_2016_07_Scotland_Energy_Strategy_2.pdf

[14] REN21. (2016). *Renewables 2016 Global Status Report.* (Paris: REN21 Secretariat). http://www.ren21.net/wp-content/uploads/2016/06/GSR_2016_Full_Report.pdf

huge hydroelectric generation capacity, while in Sweden biomass is much the largest renewable energy source. None of these options are available at scale to Scotland in the next 13 years. We further note that this enables extensive electrification of heat supply in Norway, and a combination of electrification and biomass (district heat) in Sweden.[15] Both countries also have more energy efficient housing stock than Scotland.

**A variable renewable electricity-based energy system presents a compelling delivery challenge.** It presents a core structural choice of how much to rely on linkage to external electricity supply to enable balancing of surplus/shortfall generation. This is especially the case when addressing seasonal variation, where demand-response management of energy consumers has less potential. A high reliance on interconnection would likely have lower costs and perhaps greater feasibility than seeking a more localised balancing of energy production, which would require massive new energy storage capability and/or low-carbon thermal generation (biomass, or hydrocarbon or biomass with CCS). In both cases, however, the delivery timescale envisaged in a 2030 target is extremely challenging and, at least in part, is subject to decisions outwith immediate Scottish Government control.

### Bioenergy carbon neutrality and sustainability:

The generalised status of bioenergy as a renewable resource is coming under increasing scrutiny and criticism. The scope for bioenergy resources to meet stringent carbon sustainability criteria is necessarily limited, so it is **important to consider where best to make use of bioenergy,** for example, in roles where other options are limited or unavailable, such as heat provision in locations not connected to gas grids. These uses might not be those which, compared to other uses, achieve the greatest overall contribution to the proportion of energy derived from renewable sources. Similarly, bioenergy with CCS could contribute very effectively to emission reductions. However, against a “renewable consumption” target, it might be accounted unfavourably compared to bioenergy without CCS, due to the CCS process energy requirement, which reduces net output. Hence, policies accompanying and supporting the renewables target should perhaps reflect restraint on general bioenergy usage. We hope these points will be given consideration in the forthcoming Bioenergy Action Plan and we would be very happy to contribute directly to this.

## 5 Question 4: *What are your views on the development of an appropriate target to encourage the full range of low and zero carbon technologies?*

Building on our comments on Question 3 above, we firstly **urge the clear primacy of the decarbonisation targets over sector-specific or technology targets**. Nonetheless, as argued above, these can fulfil important policy roles in supporting delivery.

Here, we note that as Brexit progresses there is a real possibility that the UK, and so UK-located power and industry emitters, will no longer be part of the EU Emissions Trading

[15] Swedish Energy Agency. (2016). *Energy in Sweden 2015.* https://energimyndigheten.a-w2m.se/FolderContents.mvc/Download?ResourceId=5545

Scheme (EU ETS). If so, the current "traded sector" emissions envelope approach may no longer be applicable and **UK and Scottish Governments will have to develop a replacement mechanism to regulate and reduce emissions from EU-ETS sectors.**

Scotland's industries are of great value to the Scottish economy and so need special attention. The largest industries are ideally located to form a low-carbon industrial CCS cluster, with removal of $CO_2$ through sharing the onshore No.10 Feeder pipeline to link to North Sea $CO_2$ storage.[16] We therefore advocate that **Scottish Government should consider establishing a target for the tonnage of $CO_2$ captured and stored from industry by 2030.** This can be numerically based on TIMES model analyses in consultation with potential project developers. Such a target would provide an opportunity and imperative for industry engagement and collaboration. Alongside, Scottish Government might consider **a multi-stakeholder CCS action plan to coordinate work on the actions presented in the Energy Strategy**. This would examine and develop the support and incentives needed to deliver large-scale CCS operations to the timeline envisaged in the Scottish Climate Change Plan.

Similarly for hydrogen, following development and assessment of the route-map suggested in the new energy sources actions (page 36), Scottish Government might consider a **target for the proportion of heat derived from hydrogen, or for the extent of change from methane use to hydrogen** to engage with and give confidence to this emerging industry.

Lastly, we welcome the commitment by Scottish Government to bring forward a revised and more ambitious Scottish Climate Change Bill in line with the 2015 UNFCCC Paris Agreement. Article 4 of the Agreement endorses science from the Intergovernmental Panel on Climate Change, which recognises the need for emissions to reach "net-zero" to stabilise climate change. This aim is partly expressed in the 2050 vision of the draft Energy Strategy, which includes "almost complete decarbonisation of the energy system". Recent advice from the UK Committee on Climate Change also considers possible higher ambitions for 2050 emissions reduction targets.[17] In light of this, we suggest that any **interim targets in the Energy Strategy, and related actions and investments, should be assessed for their compatibility with a trajectory towards the objective of near-complete decarbonisation by 2050**. This date is only 33 years away and so is well within the lifetime of energy infrastructure decisions and investments. An example of the importance of assessing for compatibility with the 2050 objective would be some heat network system designs that depend on fossil-fuelled combined heat and power systems. These systems offer a substantial improvement in efficiency with resulting emissions reductions. However, they do not achieve near-zero emissions, so while they could contribute to interim targets, they would not achieve the 2050 objective and could therefore be a future barrier to its achievement.

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[16] Peter A. Brownsort, Vivian Scott, R. Stuart Haszeldine. (2016) Reducing costs of carbon capture and storage by shared reuse of existing pipeline – Case study of a $CO_2$ capture cluster for industry and power in Scotland. *International Journal of Greenhouse Gas Control*. **52**: 130-138. (Full paper available on request from peter.brownsort@ed.ac.uk).

[17] Committee on Climate Change. (2017). *Advice on the new Scottish Climate Change Bill.* https://www.theccc.org.uk/wp-content/uploads/2017/03/Advice-to-Scottish-Government-on-Scottish-Climate-Change-Bill-Committee-on-Climate-Change-March-2017.pdf

## 6 Question 6: *What are your views on the potential future of Scotland's decommissioned thermal generation sites?*

We agree that sites of decommissioned thermal generation facilities are potential strategic assets to support Scotland's future energy supply. They have a number of potential uses and existing infrastructure, such as electricity transmission and gas pipeline connections, may be reused beneficially. However, their locations and condition may not always be ideal for new uses.

Bulk production of hydrogen for replacement of methane gas as an energy vector for heat is currently achieved most cost-effectively through steam reforming of methane, which, when combined with CCS, gives a low-carbon source of hydrogen. Decommissioned thermal generation sites that are close to options for $CO_2$ storage, or options for transport to such storage, may offer beneficial sites for hydrogen production. Proximity to demand for hydrogen, through access to suitable segments of the gas distribution network or industrial hydrogen users, would also be required.

As an example, the Longannet site presents a possible siting opportunity for hydrogen production as it is reasonably close to the high pressure natural gas (methane) transmission network for feedstock, also reasonably close to industrial hydrogen users and gas distribution routes, and has a defined route to the No.10 Feeder pipeline capable of $CO_2$ transport to the offshore storage sites most likely to be developed first.

Equally, and for similar reasons, decommissioned thermal generation sites would have strategic value for siting other low-carbon energy technologies, such as biomass combustion or gasification, anaerobic digestion, or energy from waste, each of which can be integrated with CCS to deliver low- or even negative-emission energy.

We suggest that **assessing the potential of these sites in detail could be undertaken as part of the development of the CCS action plan** suggested in answer to Question 4 above, and that until such assessment has been made these sites are not released for general development.

## 7 Question 7: *What ideas do you have about how we can develop the role of hydrogen in Scotland's energy mix?*

We welcome the broad view given in the draft Energy Strategy on the roles that hydrogen could play in Scotland's future energy system and agree generally with the proposals and actions outlined. Hydrogen is a uniquely versatile energy vector, which is able to supply energy for heating, power generation and transport, as well as having industrial uses, with essentially zero-emissions at the point of use.

Hydrogen is currently produced principally from fossil hydrocarbons, through reforming or related gasification processes, which give $CO_2$ as a by-product. Hydrogen production from hydrocarbons can be rendered low-carbon by integration with CCS – capture and permanent geological storage of the $CO_2$ by-product. Hydrogen can also be produced by electrolysis, which, if using electricity from renewable sources, is also low-carbon. We believe **hydrogen production from hydrocarbons with CCS and by electrolysis from renewable electricity both have a role in the Scottish energy system and should be supported by Scottish Government**. The choice of production methods will depend on a number of factors, including location and scale of demand, availability and scale of hydrogen storage, strategic decisions on distribution network developments, and technical and economic factors.

Where variable renewable electricity generation currently has peak output in excess of demand or transmission capacity, it may be sensible to use the excess to produce hydrogen by electrolysis, either for local heat supply or to store for conversion back to electricity when required to maintain output. This application may be attractive in off-grid areas, areas with restricted grid capacity, areas with an isolated gas distribution network, as a source for individual hydrogen transport fuelling stations, or as an alternative to curtailment of renewable electricity output.

However, for **large-scale hydrogen production to supply domestic, commercial or industrial heat demand in urban areas, hydrocarbon sources of hydrogen, principally by steam methane reforming of natural gas, decarbonised through CCS, will be most cost-effective and practical.** This is a standard, established industrial technology with annual global volume of tens of millions of tonnes hydrogen.[18] Commercial-scale examples of steam methane reforming integrated with CCS are operational in Port Arthur (Air Products, Texas, USA), Fort Saskatchewan (Quest, Alberta, Canada), and Tomakomai (Japan CCS Ltd, Hokkaido, Japan).[19]

As there is room for alternative production methods for hydrogen in the energy system, we also suggest that there is room for alternative deployment tactics within an overall strategy of moving towards the widespread use of hydrogen for heat and for transport. We agree that **the approach of blending a proportion of hydrogen into the national gas distribution system can give a rapid, if limited, level of decarbonisation of heating.** If a blend proportion compatible with transport in the high pressure National Transmission System can be determined, siting of hydrogen production by steam methane reforming at St Fergus, where the $CO_2$ by-product could be stored offshore in the proposed Acorn Project developments, would be an attractive first step. However, it appears likely that hydrogen production at sites closer to heat demand may be more practical, at least in the short to medium term, allowing use of upgraded gas distribution networks already compatible with hydrogen.

In parallel with deployment of hydrogen through blending, **work to establish safe use of pure hydrogen in distributed supplies for heating or transport should be progressed as a priority**. Such developments can also be made in an evolutionary fashion by exploiting the structure of the existing gas distribution network, which has a number of districts that could be

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[18] Mari Voldsund, Kristin Jordal, Rahul Anantharaman. (2016). Hydrogen production with $CO_2$ capture. *International Journal of Hydrogen Energy*. **41(9)**: 4969-4992.

[19] Global CCS Institute. *The Global Status of CCS 2016: Summary Report.* (2016). https://www.globalccsinstitute.com/publications/global-status-ccs-2016-summary-report

segregated and supplied independently with hydrogen from distributed steam methane reforming production sites and/or by electrolysis from excess renewable electricity. Such districts include some sizeable demand areas, such as Stirling and Dundee,[20] as well as many smaller areas suitable for pilot or demonstration projects.

With careful planning, such approaches can **allow an evolutionary deployment of hydrogen, establishing knowledge and experience to incrementally and reliably allow low-carbon heat and transport for a high proportion of Scottish demand** in line with the present Climate Change Act (Scotland) and its successor's interim and 2050 carbon budgets.

## 8 Concluding remarks

Overall, SCCS strongly welcomes the recognition in the draft Energy Strategy of the vital importance of CCS and the ambition to support its delivery across multiple sectors. However, concerning CCS, the draft document is perhaps more of a "vision", than a "strategy" as it does little to clearly define the pathway and corresponding actions necessary to achieve the stated ambitions.

With the objective for "almost complete decarbonisation of the energy system" by 2050 little more than three decades away, strategic actions on energy innovations and decisions on energy infrastructures are urgently needed. We therefore recommend that for CCS the final Scottish Energy Strategy should establish clear action timelines and deliverables, in line with Scottish Government energy system analyses, to engage and support stakeholders towards CCS deployment.

[20] SGN. (2016) *Long-term Development Statement 2016, Appendix A.* https://www.sgn.co.uk/uploadedFiles/Marketing/Pages/Publications/Docs-Long-Term-Development-Statements/SGN-LTDS-Statement-2016.pdf