WP SCCS 2017-03

Net Zero Carbon Scotland:
Perspectives on shared objectives

A multi-stakeholder roundtable discussion of

Scotland's draft Energy Strategy

Author: Indira Mann

Scottish Carbon Capture & Storage

May 2017

Scottish Carbon Capture & Storage
Edinburgh Centre for Carbon Innovation
High School Yards, Infirmary Street, Edinburgh, EH1 1LZ
Telephone +44 (0)131 651 4647 www.sccs.org.uk

Table of Contents

The content for this report was provided by speakers and participants at our roundtable event held at the Edinburgh Centre for Carbon Innovation on 29 March 2017. It was gathered and collated by SCCS Team members:

Peter Brownsort

Gareth Johnson

Vivian Scott

Richard Stevenson

Romain Viguier

Event chair: Philippa Parmiter

Design and layout: Vanessa Mather

Report icons: Question by dilayorganci; Rubik's Cube by Ryan Beck; Windows by ArtWorkLeaf; Road ahead by Alexander Skowalsky (all from the Noun Project).

Net Zero Carbon Scotland

1 Foreword

By Stuart Haszeldine

The Scottish Government's draft Energy Strategy has been broadly welcomed across different sectors of Scottish society. The document sets out ambitious targets for the long-term, sustained decarbonisation of Scotland's economy and communities, and the government has been actively encouraging debate around its goals and framing.

Against this backdrop, we invited experts from different energy sectors to participate in a roundtable discussion. This report describes some key outputs from the dialogue, which will be fed back to the government's consultation. Our event sought to bring different perspectives around the table to explore potential pathways to a net zero carbon society by 2050. Of particular interest were three government ambitions, namely: 50% of all energy from renewables by 2030; 80% of domestic heat from low-carbon technologies by 2032; and commencing negative emissions from 2027.

We did not expect to reach consensus on the way forward or hope to investigate all the options open to us. And we did not start from the premise that renewables or hydrogen or carbon capture and storage (CCS) are the sole answer. Rather, we wanted to explore synergies between technologies that could help us meet decarbonisation targets in the timescales outlined.

Those of us at the table held a shared vision but we approached it from different reference points. By the end of our discussion, it seemed clear that none of the proposed remedies offer single solutions and that future pathways will continue to be dynamic and unknowable. There is no unique route: options are important. When creating policy to deliver Plan A, retaining options for a Plan B and Plan C are insurance until Plan A delivers, since we cannot accurately foresee the speed of delivery, cost or acceptability of current propositions.

Our event focused on carbon reduction rather than delivering more energy. So it is important to keep in mind the strategies and policies that aim to reduce energy demand and encourage behavioural change. Many improvements are deliverable now, including those that will reduce the call on energy. However, although demand reduction is possible, the UK Digest of Energy Statistics shows that little progress has been made since 2005. Most reduction has come from changes within industry, and most growth has been in the transport sector. Real reduction is persistently elusive. The target for delivering 80% of domestic heat from low-carbon technologies by 2032, and powering low-emission vehicles within the timescales outlined, appear to be equally elusive. Consequently, additional actions will be needed, beyond renewable energy.

Meeting our carbon targets remains the imperative. How we do that within an ever-shifting political landscape is a challenge that we must overcome with the tools we have to hand or are within our grasp. And Scotland, with its decarbonisation progress to date and a range of unique assets in its favour, is extremely well placed to meet that challenge.

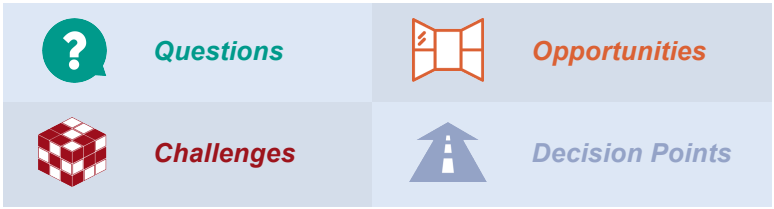
Our thanks go to all our participants for providing their time, expertise – and energy – to take part in this debate. This report represents our reflection of the views, ideas and concerns shared on the day.

2 Background

In January 2017, the Scottish Government issued its draft Energy Strategy[1], *The Future of Energy in Scotland*, with an invitation to respond to its targets and approach by 30 May 2017. SCCS invited experts from the energy and environmental sectors (**Appendix 1**) to discuss how the interplay of different ideas and technologies could deliver the strategy's ambitions. Participants were asked to refer to the strategy itself and the draft Climate Change Plan (CCP)[2], with a focus on three targets:

- 50% of *all energy* from renewables by 2030
- 80% of *domestic heat* from low-carbon technologies by 2032
- Achieving *negative emissions* from 2027

The event, held under the Chatham House Rule, sought a variety of perspectives on shared decarbonisation goals as well as key decision points needed to 2030 and 2050. Challenges and opportunities were also identified. The roundtable began with scene-setting and perspective talks from the Scottish Government and energy sector experts. The final session featured a debate on energy targets and vectors prompted by questions from the strategy document. This report summarises key points raised and uses icons, where applicable, to identify four categories:



View event presentations at: www.sccs.org.uk/net-zero-carbon-scotland

3 Scotland's energy challenge

3.1 Scottish Government's energy ambitions

An overview of the Scottish Government's draft Energy Strategy and its aims was provided by key author, Katherine White (Head of Energy and Climate Change Projects), and Stuart Greig (Head of Onshore and Subsurface Policy Unit):

- The Scottish Government, which seeks a comprehensive energy policy, used the TIMES energy system model to evaluate least-cost greenhouse gas reductions across the Scottish economy.
- The government has identified priority areas without specifying a single mix of technologies.
- The CCP shows the electricity system becoming wholly decarbonised by 2032.
- The energy strategy features three themes to pursue: a "whole system" view; a stable, managed energy transition; and a smarter model of local energy provision.
- To help achieve the "50% of all energy from renewables" target by 2030, Scotland will need to get the market right for renewable technologies, for electricity, heat, transport and energy storage.
- For local energy systems, there will be continuing support for local projects. New institutions might play a part, such as a proposed "Government-owned energy company".

[1] *Scottish Energy Strategy: The future of energy in Scotland*, January 2017 http://www.gov.scot/Resource/0051/00513324.pdf
[2] *Draft Climate Change Plan*, January 2017 http://www.gov.scot/Resource/0051/00513102.pdf

- The government is continuing its support of the oil and gas sector as well as new technologies, including hydrogen and CCS.
- Negative emission technologies could be critical for achieving CCP targets and beyond.
- CCS could provide a cost-effective, stable transition to a low-carbon energy system and the government is keen to rebuild the case for it, following the UK Government announcement to remove funding.
- The need to preserve re-usable infrastructure for CCS development has been recognised; small-scale demonstration projects are seen as the way to regain momentum.
- Scotland is well placed to develop hydrogen as a heat and transport vector, with a suitable gas grid and a large renewable sector that can use excess output for hydrogen production.

3.2 Energy system challenges for Scotland within the UK

Mark Winskel (UK Energy Research Centre and Chancellor's Research Fellow at University of Edinburgh) discussed Scotland's ambitions within the context of UK policy, given reserved powers on energy, and explored some of the challenges faced:

- The UK and Scotland differ hugely on supply and demand e.g. energy demand by early 2030s forecast to be down 15% in UK but up by 8% in Scotland.
- There is a substantial risk associated with diverging approaches, priorities and timelines e.g. a difference in heat ambitions and pathways, such as UK Committee on Climate Change view, which ranks greater efficiency over low-carbon heat delivery.
- Scotland's aim is to deliver 80% of domestic heat by low-carbon technologies; the UK target is just 1 in 7 homes. Scotland has a 94% non-domestic heat target, the UK has just 50% (by 2030s).
- The UK has differing views on CCS: Scotland looks to operate it by the mid 2020s but UK Department for Business, Energy & Industrial Strategy projections show no CCS until 2035.
- Assessing the draft Energy Strategy is challenging as it presents only a single pathway from the TIMES model, which guided the CCP, with no published detail on the other pathways considered.
- Prior experience with TIMES-type model outputs show they can struggle to incorporate social and environmental ambitions.
- Scotland's greater focus on low-carbon heat and zero/negative-carbon power compared to modest ambition on transport and industry could bring misalignment of national and local policies e.g. significant local planning and regulatory decisions taken before national strategies are clear.
- UK industrial strategy policy priorities are on industrial strategy and clean growth – prioritising energy affordability, high-tech innovation and market approach – with an absence of efficiency, CCS and low-cost renewables as part of industrial strategy, contrary to Scottish policy.
- Scotland has very high ambition in climate and energy policy but the major energy challenges are heat, transport and housing stock efficiency.

It would be useful to have open scrutiny of other TIMES pathways identified by the Scottish Government.

Scotland will need more systematic consideration of uncertainties and alternative [pathways] in the energy strategy and CCP, taking up offers of open engagement and independent advice.

4 A low-carbon pathway: three perspectives

SCCS invited speakers from different technology sectors to present their vision for meeting Scottish Government targets outlined in Section 3. They were asked to consider decision points needed on the pathway to 2030 and 2050; the means of balancing energy demand; the life cycle analysis of respective technologies; and cost and speed of delivery. Discussion points follow the talk summaries.

4.1 The renewables landscape

Lindsay Roberts (Senior Policy Manager for Sector Strategy and Development, Scottish Renewables) explained the current position of renewable energy in Scotland and the sector's future ambitions before outlining how it could reach the 50% all energy target by 2030:

- With 8 GW electricity capacity installed and 12.8 GW pre-operational (plus 4 GW in onshore wind consented and 3 GW in planning) renewable power is now meeting 59.4% of Scotland's electricity needs, exceeding the government's 50% by 2020 target.
- Renewable electricity capacity has trebled since 2007, and in 2015 it displaced 13.5 million tonnes of carbon dioxide (CO_2).
- In comparison, renewable sources supply just 5.3% of non-electrical heat demand. 1.5 GW is operational, with 60% of this from biomass, providing a total renewable heat output of 4,156 GWh. Just 2% of homes are currently fitted with low-carbon technology.
- The renewables sector has been pushing for 50% of all energy derived from renewables by 2030.
- It also seeks a doubling of installed electricity capacity and a trebling of heat output by 2030 together with a secure, viable route to market for all renewable technologies and the introduction of a renewable energy bond.
- Renewables can deliver the "50% of all energy" target by 2030 (Figure 1).

	2014 (actual)		>	2020 (predicted)		>	2030 (proposed target)	
	Renewables Output (GWh)	Renewables Output as Proportion of Demand		Renewables Output (GWh)	Renewables Output as Proportion of Demand		Renewables Output (GWh)	Renewables Output as Proportion of Demand
Electricity	18,962	**50%**		33,000	**87%**		51,500	**110%**
Heat	3,031	**4%**		6,000	**8%**		11,700	**20%**
Transport	1,295	**4%**		3,000	**9%**		3,900	**14%**
ALL ENERGY	**23,288**	**15%**		**42,000**	**28%**		**67,100**	**50%**

Figure 1: Scottish Renewables 2030 target, Lindsay Roberts

4.1.1 Discussion

Energy Strategy targets

The 50% renewable energy target is challenging. The CCP pathway using the TIMES model suggests 44% is possible, but additional Scottish Government analysis for the Energy Strategy has shown that 50% is achievable when a "high electricity export" scenario is assumed. The figure for renewable transport is more speculative and depends on penetration of biofuels, which is governed by EU Directive and the UK Road Transport Fuel Obligation. For instance, hydrogen is considered low-carbon but not renewable so does not contribute to 50% target.

50% all energy from renewables by 2030 is proposed in the strategy but a full range of targets [for all technologies] is needed, and also interim targets [Note that there is a separate question in the consultation, which addresses this point].

Supply and demand

How can Scotland deliver onshore wind without a cost subsidy?

Interconnectors (ICs) are more important to Scotland than the rest of the UK but are not prominent. With no baseload electricity (loss of Peterhead power station, coal power, nuclear, etc.), they will be needed.

An increasing priority for the government is resilience, either by interconnection or by other methods of flexibility within the electricity system.

We need ways to bridge the “wall” between renewable electricity and heat, through battery storage of excess wind power and matching supply and demand.

ICs are not connected to Scotland, should we consider building our own? 110% renewables generation (Figure 1, 2030 target) requires ability to export.

How do ICs sit with emissions standards? They are an uncontrollable and unknown source. We would need verification of embedded carbon in the source of supply.

Mature, cheap technology is ready to deploy now so we should go ahead rather than rely on other unproven technology.

Historically, we have seen interconnection as a way to deal with excess electricity. Now we need to balance the system better and will need other methods as well as interconnection.

Transport

Clarification is needed on the mix of biofuels and electricity as part of transport target figures.

By 2030, how much of transport will be delivered by electricity?

The transport target can be delivered by renewable electricity and renewable fuels. The transport figure is quite speculative. It is also a reserved matter currently dominated by EU legislation.

Heat

The difference in heat targets between Scotland and the UK is an area for concern. Is Scotland’s target overly ambitious?

4.2 A sustainable zero-carbon energy system

Stuart Haszeldine (SCCS Director and Professor of CCS, University of Edinburgh) described a pathway for balancing the carbon budget progressively between now and 2050 in order to achieve a net zero carbon society in Scotland:

- The renewables sector has made an important contribution to reducing Scotland's carbon emissions. We now need rapid innovation, testing and roll-out of all low-carbon approaches, including: CCS, increasing carbon in soils through peat restoration or biochar, and achieving negative emissions through reforestation and bioenergy with CCS (BECCS).
- CO_2-enhanced oil recovery (CO_2-EOR) could store around 10-20 million tonnes a year (Mtpa) of CO_2 if carefully balanced against the resulting oil and gas output.
- For CCS, a clear pathway is needed for preserving and deploying legacy infrastructures.
- Industry in Scotland, linked to many jobs and a large part of Scotland's GDP, emits c.10 Mtpa of CO_2 and much of this could be captured (or offset by Scottish BECCS) and stored offshore:
  - the Acorn CCS Project, at St Fergus in north-east Scotland, can be a starting point and could store 0.5 million tonnes a year of CO_2. It could be operational in three to five years.
  - The Feeder 10 natural gas pipeline, available to carry CO_2 to St Fergus, runs close to Grangemouth, where "clustered" industries could tie into CCS progressively.
  - This offers the fastest, least cost deployment of industrial CCS in Europe; the infrastructure is there, storage sites have been evaluated and over £100 million has been spent on studies.
- Scotland's offshore CO_2 storage capacity is 50-70 billion tonnes, or 200 years of emissions.
- There is a huge opportunity for hydrogen to meet the inter-seasonal energy challenge, particularly as climate targets mean that unabated methane in the energy mix declines rapidly from 2030s.
- Land/forestry use needs thought, rather than just growing and burning trees (short-term sink):
  - Sustainable wood for BECCS could achieve substantial negative emissions.
  - Biomass can be used to produce syngas, which can be separated into hydrogen and CO_2 as well as providing electrical and heat energy (e.g. Austria's Gussing plant).
  - Biochar made from domestic or biomass waste could create negative carbon emissions.

2018	Offshore pipelines preserved; hydrogen network and biomass gasification pilots
2021	Small-scale CCS; early commercial hydrogen; reforesting
mid-2020s	BECCS, biochar and possibly CO_2-EOR start to realise negative emissions
2030s	Hydrogen roll-out for heat (initially from methane); could lead to zero-carbon future with hydrogen production from renewables in 2045+

Figure 2: A pathway to net zero carbon in Scotland by 2050, Stuart Haszeldine

4.2.1 Discussion

Why has nobody taken up the commercial use of hydrogen for heat yet? Possibly due to competition from natural gas for heat and large-scale power systems for electricity.

How small is small in terms of "small-scale" CCS demonstrations e.g. a recent estimate suggested a "series of £200 million projects"? We can make a start with smaller capital e.g. £10s of millions.

The most urgent step, which needs to be taken now, is protecting from decommissioning existing pipeline infrastructure that could be used for CO_2 transport.

4.3 Future energy system enablers

Nigel Holmes (Chief Executive Officer, Scottish Hydrogen & Fuel Cell Association) delivered his future energy vision under four themes:

The seasonal energy challenge

- In Scotland, energy demand for transport and electricity is steady throughout the year but, for heat, it is highly seasonal: from lows of 50 GWh per day in summer to over 350 GWh per day in winter.
- The electricity network fits current electricity demand, which is more or less steady. However, heat demand is characterised by super-peaks and will need a very different network, if fully electrified.

Integrating renewables

- In some grid connection agreements, wind farm output is curtailed at certain times. In Scotland, up to 20% of onshore wind energy is lost this way e.g. Whitelee windfarm curtailment is 25%.
- Energy generation from renewables (solar, hydro, wind) has daily variations, fluctuating from 30-50 GW some days and 25-35 GW other days. The system makes occasional surplus energy.

The need for energy storage

- Hydrogen offers energy storage of multiple TWh scale in transport (especially for train and marine transport), in biofuel (hydrogen as a sustainable feedstock) and in affordable low-carbon heat.
- Surplus power can be converted to hydrogen by electrolysis, available for transport and heat.
- Hydrogen is a clean energy vector, a feedstock for the chemical industry, makes commodity products and is a biofuel feedstock. It can also contribute to a flexible renewable energy system.

BIG HIT (Building Innovative Green Hydrogen Systems in Isolated Territories) launches in Kirkwall in September 2017.	**CEESA 2050**[3] Denmark's "whole system" approach to decarbonised heat and transport, with a 100% renewable energy system by 2050 delivered in an economical and efficient way.
Leeds City Gate H21 A project looking into the viability of converting the natural gas network in Leeds, one of the UK's largest cities, to 100% hydrogen.	**SGN** is developing ideas for pilot hydrogen projects in Scotland and is considering different locations.

Figure 3: Live projects considering hydrogen within energy systems, Nigel Holmes

Hydrogen for low-carbon heat and grid balancing power

- Hydrogen produced from natural gas by steam methane reforming (SMR) with CCS or by renewables (electrolysis) can be stored in daily and seasonal storage using salt caverns.

[3] http://www.energyplan.eu/ceesa-100-renewable-energy-scenarios-for-denmark-to-2050-2012/

- The geological storage of hydrogen is proven at scale e.g. 85 million m^3 in Texas “Spindletop” salt cavern. This is energy equivalent to 300 GWh = 12 Cruachan pumped hydro storage projects. No onshore salt in Scotland, but other geological storage may be viable.
- End users (domestic and commercial) only need to convert/replace boiler appliances, not change whole heating systems. Appearance and functionality would be essentially identical and may be the lowest cost pathway to delivering low-carbon heat.
- Underground hydrogen storage has been designed at 1 billion m^3 scale, with salt caverns, and could be significantly larger with aquifer or porous rock underground storage (offering multi-TWh-scale seasonal energy storage).
- Designs using twin 450 MW gas turbine generators with hydrogen are available to provide long duration, on-demand 900MW power for zero-carbon electricity grid balancing.

4.3.1 Discussion

Viability, timeline and pathway

The transport challenge is currently a technical one, whereas the heat challenge is infrastructure.

It is time to take “no regrets” actions with the testing and development of technologies and approaches, both domestic and imported.

Hydrogen is new to the agenda but Scotland’s CCP suggests unabated methane cannot be part of the energy mix by the 2030s. Therefore, decisions on hydrogen will be needed by 2025 or earlier.

Consumer perspective

Householders tend to be curious about new technologies but also risk-averse and dislike disruption. Community experience and individual motivation are important e.g. money saved rather than action to reduce emissions.

Hydrogen still elicits public safety concerns e.g. the Hindenburg disaster. A big education programme will be needed.

Smart meter roll-out could have been used as an opportunity for wider contact and disseminating information on energy and efficiency. [Any other opportunities?]

Deployment approach

The challenge of emissions reduction from heat delivery is often a discussion stopper.

Generators pay to access the grid so need to be reimbursed. Do we need a less constrained grid?

What cost can/should consumers and industry bear?

As Leeds City Gate suggests, costs could be spread in a similar manner to gas network upgrades (e.g. by extending bill additions beyond 2022) rather than requiring upfront payment from consumers.

Large projects come with higher investment risk and, so far, all have failed. But the heat sector needs radical change and an ambitious project might be more appropriate than a small-scale one.

The market needs government support/cover for intervention.

Policy is needed to create a market for the production and use of hydrogen, including pre-commercial financing for supporting infrastructures.

5 A discussion of energy targets and vectors

Q1 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?

General comments

- The 50% target provides something to aim for. It is challenging but we might as well stretch for it.
- It is good to have specific sectorial targets as well as targets allocated to technologies.
- Should the terminology be "low-carbon" – not just renewables – to include CCS and hydrogen?
- We already had targets for renewables, we could have a decarbonisation target instead.
- Renewables targets are popular: better to have that or technology-specific targets rather than least-cost.
- The target is good; it took a long time to get the network in place for current levels of renewables.
- Have a consumption-based target (assumes energy efficiency and reduced demand)?
- How do we manage biomass and where it is put to most use i.e. combusted and/or providing emissions reduction? How would that feed into a consumption target?
- Is energy consumption a bad thing? No, a growing economy needs energy. Are carbon emissions bad? Yes. So perhaps targets should be based on "per capita" use or energy intensity of industry.
- The policy framework is not ready for BECCS.
- A 50% target is good but [be aware that] overall energy consumption in 2014 was 47% for oil and gas products and 25% consumed in the transport sector.

Industry

- CO_2 emission targets help industry decarbonise. The challenge can be met by clustering around shared infrastructure; this will attract other emitters – i.e. companies – to such areas.

Cost

- TIMES is just a mechanism not a policy and Scottish Government has recognised advantages that are not purely to do with cost e.g. jobs, supply chain, etc.
- How will this be paid for? What impact on bills? What is the least costly solution for consumers?
- The market won't necessarily go to where it is most needed so a planning system can guide this.
- How do you incentivise innovation and cost reduction?

UK-Scotland divergence

- How do we link the Scottish targets better to the UK's industrial strategy?
- Will the UK's divergence on energy matters, much of which is reserved, adversely affect Scotland's approach to decarbonisation?

The economy

- What does the 50% target mean in terms of jobs? Supply chain, rural communities and international opportunities? Would certain technologies give Scotland an international advantage?
- Are Scottish locations that offer low-carbon electricity/feedstocks an advantage? How do you package that to draw people in?
- Questions remain around the flexibility of renewables; how much can there be and what cost?

Q2: What are your views on the development of an appropriate target to encourage a full range of low and zero-carbon energy technologies?

General comments

- We need specific and challenging targets to develop a range of technologies and get us out of the comfort zone. How else do you encourage action?
- Targets should include energy services as well as technologies.
- Targets are popular but must "land" right; government should lead but in partnership with public.
- A "low-carbon" target is sensible as a back-up/second tier to 50% renewables target.
- The market approach is not working for the energy system but governments are not good at taking big decisions either.
- There are challenges and decisions to be made about how we get hydrogen and BECCS started.

Timing and delivery

- 15 years is not a long time for major shifts in market or culture (e.g. the roll-out of broadband).
- Strategic decisions need to be made soon, such as the future use of the gas grid.
- The commercial market will only deliver about 66% of the target coverage so we will need ways to deliver the rest.
- "Carrot and stick" may be the way to achieve targets:
  - use a prize, like the Saltire Prize, to incentivise, focus and internationalise developments
  - link prizes to the biggest exporting sectors, such as chemicals (e.g. for transition to sustainable feedstocks) and whisky (challenging the sector to go further than it already has).
  - the Saltire Prize proved difficult for renewables but it was a good marketing idea and there are other good examples of the prize approach worldwide.
- The "Scottish energy company" could provide leadership for Scottish and UK governments.
- There are issues around infrastructure. It is difficult to see how renewables can decarbonise [80% of] heat. So how do we get investment into low-carbon infrastructure started?
- Uptake can be encouraged in some [sectors]; for instance, the uptake of district heating in new-build housing developments, but developers may need to be forced to do this.
- Government needs to feel it is in a partnership for the delivery of projects with industry.

Cost

- It is hard to get the public behind investments driven by carbon reduction. A narrative is needed to communicate and justify the need for investing public money in low-carbon infrastructure.
- There is a role for government/public funding where there is no clear market and/or when it would be inequitable to burden consumers with the costs.
- Can Scotland invest in large infrastructure? £100s millions of public funding are not available for large projects. [Small trials can create confidence that leads to bigger investment.]
- When was the last time major energy infrastructure was publicly funded by direct investment, like motorways or high-speed rail? (The "Bootstraps" – offshore interconnectors – is one example).
- We need to know the costs of different options for energy systems [from developers] but cannot rely on market mechanisms for some infrastructure changes e.g. 100% conversion to hydrogen for heat.
- We also need ways to encourage private investment e.g. like Liberty buying the Fort William aluminium smelter, bringing local jobs and benefits to the economy.
- We need government to create the environment that attracts private investment.

Delivery

- For developmental change, the market can work and be technology-specific, but for infrastructure change, we need another approach, such as de-risking by funding demonstration projects.
- Decisions are being made implicitly or explicitly that will determine routes e.g. choices in Scotland's Energy Efficiency Programme[4], so how do we shape those decisions over 2-3 years?
- The market gives an optimal approach. Do we really have an optimal approach in energy? Also, government intervention means it is not market-led.
- The "Scottish energy company" could "carry the national consciousness"; buying in en masse is also very important.
- Infrastructure transition must be carefully thought through. Markets do get [delivery] costs down.

Q3: What ideas do you have about the role of hydrogen in Scotland's energy mix and the development of hydrogen production in Scotland?

General comments

- If we are serious about carbon reduction then we need to ban methane for heat after 2030. What are the alternatives? Electrification (renewables) is not currently realistic due to demand peaks.
- We are seriously stuck on this. Is the 2030 target misleading and we need a 2050 target too?
- Hydrogen may be on the menu now, but it wasn't four years ago; the landscape could all change again so hydrogen must make a strong case.
- Let's keep up efficiency measures and learn more about hydrogen in the meantime, sharing information and best practice – new technology will be key.

[4] *Scotland's Energy Efficiency Programme* (SEEP), http://www.gov.scot/Topics/Business-Industry/Energy/Action/lowcarbon/LCITP/SEEP

Public perceptions and cost

- People are risk adverse and will also be concerned about how “messy” the change will be. Many will not see the low carbon benefit because cost is the main issue for most.
- Can government help with the cash-flow problem and take on cost/risk? A bank to ease people into low-carbon choices? Green Deal did not work well [in the UK, Home Energy Scotland fared better]. Refit does work in Germany (at state scale) so maybe we just need a better version.
- We must avoid the situation where consumers cannot afford the change: could we spread the cost over time and eventually pass it on to consumers?
- Consumers should see no change in bills, only a change in their boiler. We’re currently paying for gas network upgrades in our domestic bills: £30bn over 30yrs means a small charge to consumers and makes it affordable.

Delivery

- Delivery is all about deployment. Look at international context, e.g. diesel car bans, smart grids etc. are already happening elsewhere.
- How long do we have until a decision on our approach must be taken? Is 2025 the deadline?
- There is currently no mechanism for buying and selling hydrogen. It is tempting to focus on technology but bigger issue is how to create the market over 20 years and beyond.
- A distribution channel for a hydrogen economy should be developed (producer, distributor, users).
- We need a plan in place so that investment can be made; the private sector needs security.
- Knowledge sharing is essential around areas of new technologies.
- Will the market decide on technologies used? At the moment, three or four technologies are able to compete.
- There are lots of exciting international projects on low carbon – use Scottish expertise and projects that will bring jobs and economic benefit to Scotland.
- Norway combines renewables with oil and gas under a single organisation – can we also simplify the landscape in Scotland?

6 Concluding comments

This report aims to provide an accurate summary of the discussions held during the SCCS roundtable, which were framed by the contextual talks and prompted by defined talking points. Given the range of viewpoints represented, the event was unlikely to produce a consensus view on the way forward for Scotland’s energy policy. However, as intended, it did elicit a wide range of questions, opportunities, challenges and suggested decision points for the Scottish Government to consider as part of its consultation process. The event also brought together experts from across the low-carbon spectrum to discuss freely the issues surrounding the delivery of a sustainable and resilient energy system. It is hoped that these conversations will continue outwith the usual silos. If we are to make the transition to a net zero carbon society by 2050, this will be an essential part of the process.

Appendix 1 Participant organisations

- Aberdeen City Council
- Atkins
- British Geological Survey
- Changeworks
- ClimateXChange
- Edinburgh Centre for Carbon Innovation
- Energy Saving Trust
- Global CCS Institute
- Pale Blue Dot Energy
- Scottish Council for Development and Industry
- Scottish Cities Alliance
- Scottish Enterprise
- SEPA
- Scottish Government
- Scottish Hydrogen & Fuel Cell Association
- Scottish Renewables
- Sweco
- UKERC
- University of Edinburgh
- University of St Andrews
- University of Strathclyde
- WWF Scotland