**THE GEOLOGICAL SOCIETY**

# SUBMISSION TO ROYAL SOCIETY OF EDINBURGH CONSULTATION ON SCOTLAND'S ENERGY FUTURE

1. The Geological Society (GSL) is the UK's learned and professional body for geoscience, with over 12,000 Fellows (members) worldwide. The Fellowship encompasses those working in industry, academia, regulatory agencies and government with a broad range of perspectives on policy-relevant science, and the Society is a leading communicator of this science to government bodies, those in education, and other non-technical audiences.

2. This response has been produced with input and comments from our Fellows working in the energy sector in Scotland. On UK-wide issues such as Carbon Capture and Storage (CCS), the Society has been active in responding to inquiries on this topic at a UK-level via the former Energy and Climate Change Committee or through the current Business, Energy and Industrial Strategy Committee among others. While our comments on CCS are not focussed specifically on work within Scotland, the majority of UK CCS sites will be located in the North Sea and thus the Scottish government, along with industry and skilled professionals in the region, will have a vital role in implementing this work.

3. We have not attempted to answer all of the questions outlined in the call for evidence but instead have responded on points as they relate to geoscience, geoscientists working the sector, and the energy landscape in Scotland.

## Energy Landscape

**What are the most significant challenges to, and influences on, the energy landscape that any future energy strategy needs to take into account?**

4. It is the view of our Fellows working in this area that the main outstanding challenges in the energy landscape relate to heating, peak electricity demand and energy storage.

5. **Heating**: In terms of heating, the majority of properties, both domestic and commercial, rely on gas for heating and hot water. Of the remaining properties where access to gas is not available, a significant proportion use oil instead. Against a backdrop of diminishing resources and the need to decarbonise the energy market, an overreliance on oil and gas will increase uncertainty around energy security over time. Any sustainable energy strategy needs to look into

options for a progressive change away from gas heating. Without a properly thought-through and effectively implemented policy, there is a very real risk that large numbers of the Scottish population will find themselves in fuel poverty in the future.

6. **Peak electricity demand**: Electricity usage in Scotland (and the wider UK) is well known to have spikes – often correlating with advertising breaks in very popular television shows. It is therefore necessary to have fast-response generation options that can cater for such high demand. Pumped-storage hydro is one suitable option, but gas turbines provide the main provision at present. Most renewable electricity sources, and nuclear, are not capable of coping with short-term high demand spikes. Social changes may reduce this demand in future, but this change is likely to be slow to occur.

7. **Energy storage**: Relating to peak demand, energy storage is essential as a way to smooth out the peaks and troughs of generation that are associated with renewable energy sources. For example, solar generation occurs during the day, but power needs continue in the dark. We still need heat energy and electricity during cold, still days in winter when wind turbines are not producing power. The peaks and troughs can be smoothed to an extent by having a broad mix of generation types (solar, wind, wave, tidal, hydro-electric, geothermal) but there will still be times of over-generation when excess energy needs to be stored, and times of over-demand when the population's needs outstrip the available production capacity. Pumped-storage hydro is one option, which will continue to be important, but we need additional means for storing energy both for short-term smoothing and for longer-term distribution. There is research ongoing (in Denmark) looking at the potential for storing heat underground, such that excess heat from summer can be stored for use during colder weather. This is at an early stage but may repay investigation.

**The Energy Mix**

**What overall role should be played by various elements of the energy landscape, for example:**

- **Different sources of renewable energy;**
- **Offshore oil and gas;**
- **Unconventional oil and gas;**
- **Nuclear power;**
- **Energy storage;**
- **Others**

8. **Offshore oil and gas:** Given the UK's current reliance on gas for heating and electricity production, and oil for transport, as well as both for chemical feedstocks, the future demand for offshore oil and gas is unlikely to decrease. However, taking account of legally binding climate change targets and the declining reserves in the North Sea, any future offshore oil and gas exploitation will come with challenging conditions (e.g. deeper water; greater offshore distances) and comparatively high costs, which will affect the economics of the industry and may impact on its viability.

9. **Unconventional oil and gas:** Geological studies of Scotland suggest that the shale petroleum potential in Scotland would likely be for shale oil, with a relatively minor potential for shale gas. There are debates as to the potential resource and extractable reserve, and there are diverse views in the geoscience community and more widely as to whether these are likely to be significant in a national (UK-wide) sense. The co-location or proximity of geological formations with shale oil potential to the main population centres in Scotland may be a significant factor in determining what resources will be extracted in practice. It is also debated whether the shale horizons have reached suitable temperatures and pressures to have matured. Coal bed methane (CBM) may be a more reliable prospect. There is debate regarding how to define rules and guidelines (e.g. minimum distances) for extraction of CBM near old mine workings to ensure safety and engender public confidence. Much of the coal is also below or adjacent to the main population centres and there will therefore be practical challenges to commercial extraction. Coal mine gas may have a future, if it can reliably be collected. Fugitive emissions from mine workings are known to contribute to greenhouse gases in all the former coal mining areas of the UK. Whether there is sufficient volume escaping and whether the gas can be captured effectively for this ever to be commercially viable are two questions that remain to be answered. We are not aware of any studies into this area.

10. **Geothermal:** Ground-source and geothermal energy are often overlooked in a UK context, as we don't have the high heatflow of places such as Iceland. However, given that a large part of the energy demand is for heating, it would be sensible to give more consideration to geothermal energy. There is potential for use of mine water in areas like Glasgow, where heat can be extracted from warmer, deep mine water using heat pump technology and the cooled water returned to the mine system in a different location. The British Geological Survey has done a considerable amount of work into the use of mine waters in Glasgow for domestic heating. An overview of this work can be found on their website:

http://www.bgs.ac.uk/research/energy/geothermal/heatEnergyGlasgow.html. Some trial studies of low-temperature geothermal energy have been undertaken (e.g. at Guardbridge, near St Andrews) and report positively on the findings. Geothermal energy is best used in a district or community heating scheme, so the main challenge may be retrofitting old building stock with a suitable heating system rather than the geothermal energy itself.

**Climate Change and Renewable Energy**

**What action needs to be taken to ensure that Scotland fulfils its climate change obligations while also meeting demand; and what are the main obstacles to achieving this?**

11. There are challenges both at various levels, from domestic to system-wide. In terms of domestic changes that need to be made, there are two main issues to be dealt with: effective heating and electricity demand; and a key issue at the system level is Carbon Capture and Storage (CCS). These challenges need to be addressed if we are to reduce our reliance on gas and oil and meet legally binding climate change obligations.

12. Changing space and water heating from gas and oil to an alternative is likely to be expensive and complicated. There are various alternatives – electric heating, which is costly and not very efficient; ground source heat pumps, which require space, need an electrical input to operate and are expensive to install; various forms of geothermal, which would serve best in community or district heating schemes which are largely absent in the UK; and improved thermal efficiency, through insulation and passive heating. All these options would require significant time and financial investment and are most likely to require legislation, and probably subsidy, to make any widescale change take place.

13. As previously discussed, electricity demand is variable, as is power from renewable sources. This means there is a need for energy storage, to balance the generation and demand patterns. Some changes in energy usage are likely to increase electricity demand specifically – the rise in use of heat pumps and electric vehicles will have an impact that may be difficult to quantify.

14. Implementation of Carbon Capture and Storage (CCS) is key to meeting the commitments outlined in the Climate Change Act and the Paris agreement and is essential to avoid dangerous climate change. The need for rapid rollout of CCS was reiterated in the House of Commons Energy and Climate Change

Committee (ECCC) Report on the Future of Carbon Capture and Storage, published in 2016. The committee concluded the following: ‘Without CCS it may be necessary to find large and potentially more expensive carbon savings to meet the legally binding targets set out in the Climate Change Act as well as the more recent challenging ambitions set out at the Paris climate summit’. The report also stated that if we stick to the 'with gas and without CCS' scenario we will not remain on or near the least cost path to our statutory decarbonisation target. This need was underlined in the Report of the Parliamentary Advisory Group on CCS which states that ‘carbon capture and storage is an essential component in delivering lowest cost decarbonisation across the whole UK economy’ and that ‘heavy costs will be imposed on current and future UK consumers by a continued failure to enact an effective CCS policy’. Currently, the government’s policy in this area is hanging in the balance following the cancellation of the CCS commercialisation competition. Officially, CCS continues to have a ‘potentially important’ role in this government’s energy policy, although there is no indication of what would fill its place should it not be delivered at scale by 2030. It is the view of many in the sector that CCS is critical infrastructure for secure access to energy in the future for both Scotland and the remainder of the UK, and for meeting decarbonisation targets. The retraction of the funding allocated to the CCS commercialisation competition damages the relationship between Government and industry. In this way, and more widely, UK government policy has not been conducive to investor confidence in CCS, or in the energy sector as a whole, as highlighted by the ECCC’s 2016 report on investor confidence (and in the Geological Society’s submission to this inquiry). If a clear strategy is not set out very soon then knowledge, investment, assets (including depleted hydrocarbon reservoirs and associated infrastructure, predominantly in the North Sea, which will otherwise soon be decommissioned) and expertise in Scotland and the rest of the UK will be lost.

15. CCS requires national and local infrastructure planning to make the most of current capacity, much of which is located off the coast of Scotland. This will require integrated regional and local planning to deliver $CO_2$ to geologically suitable storage locations. In addition to the technology which is now established, the next step is to develop key infrastructure to link the capture sites to transport infrastructure and storage sites in order to demonstrate the technology and delivery chain at scale. This is the key part of the delivery chain that requires focus and political momentum to move this development forward. As with many innovation projects, early on the costs are high but this decreases significantly over time as technology deployment matures and infrastructure is developed. The wealth of knowledge and assets pertaining to oil and gas exploration and

extraction in the north-east of Scotland and the infrastructure in the North Sea could create the conditions for the UK to become a world leader in CCS research and development. There is also scope to use exhausted oil and gas reservoirs around the UK in the North Sea and elsewhere as ‘storage tanks’ for gas as part of a focus on new energy storage technology.

16. We note that nuclear energy is a low-carbon source of power, albeit one that is contested and brings its own challenges including decommissioning, long-term management of wastes, and understanding and apportioning full life cycle costs and liabilities. Scotland currently relies on nuclear power generation for a large proportion of its electricity. Irrespective of whether nuclear new build plays any part in Scotland’s future energy mix, it is essential that a sustainable long-term solution is found for the higher level radioactive waste that has been generated to date, and that which will arise from the continued operation and eventual decommissioning of existing nuclear plants. The Scottish government’s policy of indefinite surface storage of this waste is at odds with that in the rest of the UK and most other countries with civil nuclear power programmes that have given serious consideration to the challenge of managing this waste in a way which is equitable to current and future generations. There is a high degree of confidence in the geological community that deep disposal of such waste in an engineered multi-barrier facility in an appropriate geological setting can be achieved safely. Some nuclear materials have been moved from Scotland to Sellafield in recent years (where presumably its eventual fate is expected to be geological disposal as part of the England/Wales/Northern Ireland disposal programme). This option may not continue to be viable in the long term, especially in the event of Scotland becoming independent.

**Environmental Impact**

**What are the environmental impacts of individual elements of a future energy mix, to what extent can these be mitigated, and how can any remaining waste products be dealt with?**

17. It is important to reconcile renewable energy projects and potential associated environmental impacts including habitat loss, particularly with relation to peatlands. Peatlands are an important carbon sink and are also a sensitive habitat. Many upland areas in Scotland have extensive peat cover and developments in these areas inevitably involve some peatland loss or damage. This can be minimised by careful design and equally careful construction and restoration, but this would need proper guidance and enforcement to be universally undertaken.

18. Beinn Tharsuinn wind farm (near Alness, Highlands), which began operating in 2005, is an example of both good and poor reinstatement. The initial section of track from the site entrance has regenerated well, as the reinstatement was being managed by a thorough and experienced environmental clerk of works. The contractor decided after a few kilometres that this was too expensive, brought in a different environmental clerk of works and undertook a significantly less thorough job. The difference remains clearly visible (see aerial imagery on Google maps or similar).

19. A concern relating to shale gas/oil is disposal of waste water. The produced water from shale gas sites is typically highly saline, highly mineralised and often contains naturally occurring radioactive material. This water is difficult to treat sufficiently to allow safe disposal to the environment. Use of desalination has been suggested, but disposal of the concentrated brines is more difficult than the initial waste water and the process is also expensive and energy-intensive. Discharge of brines to sea can have unwanted side effects, as observed in the Persian Gulf –high levels of abstraction for drinking water and the associated discharge of brine is leading to hypersaline water and a series of negative ecological effects in the gulf, as there is insufficient mixing with the Arabian Sea to counteract this. An extreme version of desalination has been suggested, where clean water and a highly concentrated brine are produced – the brine may be suitable as a chemical feedstock (e.g. for production of sodium bicarbonate and calcium chloride; https://www.scientificamerican.com/article/desalination-breakthrough-saving-the-sea-from-salt/) and have a market value. The main difficulty with this process is the energy input requirement, which makes it uneconomic at present although this may become more attractive in the future.

**Ethics, Social Issues and Impact on Communities**

**What account should be taken of the environmental and social impacts on those living elsewhere in the world, of the international energy supply chains on which we may choose to rely?**

**What are the particular advantages enjoyed, and challenges faced, regarding energy; and what lessons can be learned on a national scale from community energy schemes undertaken by:**
**a) Rural and remote communities**
**b) Urban Communities**

There are good examples in Scotland of where rural or remote communities have implemented successful local energy schemes. Lerwick in the Shetland Islands has a combined heat and power plant, which feeds into a district heating scheme. This is advantageous, both in minimising waste to landfill and in providing relatively low-cost heat energy to the community. Similarly, Stornoway (Western Isles) has an anaerobic digestion plant that uses organic waste to produce biogas (for electricity), liquid fertiliser and compost that are used to improve the soil fertility. As with the plant in Shetland, this helps to minimise waste going to landfill as well as providing useful by-products for the local community.

Integrated heating and cooling systems in urban locations can be valuable, especially for situations where housing and industry/business are close to each other, where waste heat from cooling one part of the complex is used to provide heating for a different part. This only works on a relatively small scale, as otherwise heat losses would be significant, but we understand this has been implemented effectively in some universities where computing facilities and some laboratories require temperature-controlled spaces and the waste heat can be put to good use in other areas.

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