



The Economics of Renewable Energy

1. The Royal Society of Edinburgh (RSE) is pleased to respond to the House of Lords Economic Affairs Committee Inquiry into 'The Economics of Renewable Energy'. These comments have been prepared by a number of expert Fellows of the RSE.
2. It is hoped that the Inquiry will view renewable technologies in the light of an overall energy strategy. Partitioning of thinking with regard to technology options and choices should be avoided as there are interesting opportunities for making progress towards a much higher degree of sustainability. To prepare for the longer term, investment in the development of alternative sources and cleaner technologies is essential.
3. Displacing or supplementing fossil derived energy with renewable derived energy is a truly formidable challenge because of the scale of the problem, the incompatibility of infrastructures required and the complex interactions between technical, policy and economic aspects. The myriad supply and demand-side options require an integrated approach. Solutions need to be pursued at all scales.
4. Research, development and demonstration of projects are paramount and these aspects should be built-in to a programme and not treated in isolation to one another. The real benefit of full scale demonstrators is their potential to provide confidence in a technology.

1. How do and should renewables fit into Britain's overall energy policy? How does the UK's policy compare with the United States, Australia, Canada, and other EU countries?

5. The majority of the UK's natural resources in wind, hydro, marine and biomass energy are found in the north of the UK. In fact 50% of the UK renewable energy production is sourced from Scotland¹. The Scottish Government has recently increased its challenging target for the proportion of Scotland's electricity to be generated from renewables from 40% to 50% by 2020. However, it is important to note that abundance of resource does not necessarily result in its utilisation as that resource must be harnessed effectively and economically.
6. The importance of renewable energy is that it reduces "whole life" CO₂ emissions from overall electricity production and it increases the diversity of fuel resources and hence security of supply. It has a disadvantage in terms of

¹ The Energy Technologies Partnership, Expression of Interest in Support of the UK Energy Technologies Institute (February 2007)

its increased cost – which electricity consumers bear. The only mature renewable, apart from hydro-electricity, is onshore wind which now compares broadly in cost with conventional forms of generation.

7. The support for renewables internationally is typically given by one of two means:
 - (i) a Renewable Obligation and renewable certificates as in the UK, and certain states in the US, which obliges electricity supply companies to derive from renewables a prescribed proportion of the electricity that they sell;
 - (ii) a 'feed-in tariff', as adopted in many EU states, which runs contrary in important respects to the concept of a free market in electricity. Germany, Spain and Denmark have the highest penetration of renewables in the world and have feed-in tariffs.
8. The size of a country, its political ambitions, meteorological climate and existing electricity system will influence the way in which renewable policy is adopted.
9. The exploitation of renewable energy offers significant opportunities for manufacture and export, as well as providing employment in site development, management and maintenance. At present there is a realistic prospect for the UK to develop a world-leading marine renewables industry, but this will only flourish if the right environment, including maximising bureaucratic efficiency, is provided: a substantial domestic market, with stable trading conditions to encourage steady growth. Initial costs will be high and technical risk significant. Both will reduce over time as the industry matures; the experiences of wind power exploitation are relevant here. A sizeable public investment is required in the early stages, with financial returns beginning to emerge after perhaps ten years.

2. What are the barriers to greater deployment of renewable energy? Are there technical limits to the amount of renewable energy that the UK can absorb?

10. Planning, public consultation and the democratic process generally, specifically in relation to onshore wind farms, form the greatest barriers to increased deployment of renewables. Grid connections and infrastructure, and the technical difficulties in maintaining quality of supply in remote areas, are other prominent factors. We understand that Ofgem and DBERR are conducting a Transmission Access Review to improve the transmission access regime. Bottlenecks due to delays, lack of technically-skilled human capital and competition for the supply of components are hindering deployment of renewable energy in the UK.
11. A consequence of the GB electricity transmission charging regime is that generators in Scotland face higher connection charges compared to generators elsewhere in GB because of their distance from centres of demand. This could act as a disincentive to renewable energy generation in Scotland. Although we understand there are plans to review the system of charges.

12. Renewables are typically small in scale and specific per-unit capital costs (£/kW of capacity) are thus higher than for conventional generation which may be 100 – 200 times larger in generator size. The economics are thus less attractive to developers when compared with conventional power sources, e.g. CCGT, unless there is significant support from third parties.
13. With regard to the deployment of offshore wind, wave and tidal technology, ultimately, the gap between capital costs, expected operational costs and revenue still remains too large for substantial industrial commitment, without improvements in the ROC system. Basic research, e.g. into wave behaviour, needs to be enlarged, while development and implementation costs are mostly prohibitive. Uncertainty about real future costs, particularly the installation, operating and maintenance costs is a major problem. Turbine prices are increasing as global demand expands, reliability is uncertain and raw material prices are high. It is important that work take place to establish whether some of the above risks can be mitigated, by a regime of capital grants and adjustments to economic instruments.
14. At about 20% penetration, intermittent renewable generation e.g. wind may well increase system operating costs significantly from the running of flexible and part-loaded plant. Deployment of storage capacity would help to balance the grid, which would be operating with an increased proportion of variable, intermittent renewable generation. Although this also carries cost implications.

3. Are there likely to be technological advances that would make renewable energy cheaper and viable without Government support in the future? Should, and how could, policy be designed to promote such technological advances?

15. Please also see above.
16. We will need significant technical advance in all technologies (except perhaps onshore wind) before we could say that renewable energy is both reliable and economic. The scale of most technologies would have to increase enormously if costs are to be reduced.
17. In respect of policy to promote technological advance, UK R&D expenditure in the electricity supply industry has been at an all-time low in the years since privatisation and has not always been concentrated in the right areas. More publicly funded R&D could improve matters if carefully expended. Ironically, the rising price of oil and other commodities could alleviate the uncompetitiveness of renewables.

4. Has Government support been effective in leading to more renewable energy? What have been the most cost-effective forms of support in the UK and other countries and what should the balance be between subsidies, guaranteed prices, quotas, carbon taxes and other forms of support? Should such support favour any particular form of renewable energy over the others? For instance, what are the relative merits of feed-in tariffs versus the UK's present Renewables Obligation Certificate (ROC) regime?

18. The UK Government's levers to shape the market to the national interest consist of taxation (frequently passed on to the consumer), subsidies (ultimately paid for by the consumer) or regulation. The various forms of support for renewable energy were discussed in 1 above. The ROC regime is designed to be technology neutral and encourage diversity of electricity generation. However, undifferentiated ROCs will always lead to industry employing the lowest cost option. As a result, onshore wind turbines have become commercially viable, but this mechanism has not stimulated development of other renewable sources other than for local use. We note that the ROCs are set to continue to 2027. The RO scheme is forecast to cost UK business and domestic customers over £30bn².
19. In order to bring forward emerging renewable technologies, "banding" of support levels for different technologies has been proposed. This effectively distorts the market still further, which, some would argue, is contrary to Government competition policy, and tends to encourage the "picking of winners" by those not competent to do so. This form of subsidy could also lead to the implementation of immature and inefficient technology if providers decide to off-set the costs of research and technical development by the subsidy received. Additionally, in Scotland a Marine Supply Obligation (MSO) was introduced in 2007 to provide additional encouragement for the development of wave and tidal sources located in Scotland. However, the MSO is currently set at zero because there is not eligible capacity availability which would enable suppliers to meet it.
20. In the case of wave technology, devices that have been developed and demonstrated are highly subsidised. The *Pelamis* project in Portugal is subject to a guaranteed price for its electricity for 15 years.
21. We have profound doubts about the rationale and validity of the ROCs system. As noted above, it is designed to be technically neutral at the point of production of renewables, but is not designed directly to stimulate the reduction of carbon emissions. It seems, in practice, that the mechanism provides technology-led outcomes rather than emissions reduction outcomes. We propose, therefore, that ROCs are replaced with a scheme targeted on the reduction of carbon emissions. Incentives and disincentives applied at the point of production, in direct support of objectives, leave the market to decide how best to meet the national requirements, are truly technology blind, and may encourage investment in research to find new and more efficient means of meeting the objectives. There are various mechanisms which could be implemented to achieve this, such as trading schemes or levies.
22. We referred to R&D expenditure in 3 above, but specifically in terms of the average annual per capita R&D spending on renewables 1990-2005, it was a

²<http://www.ofgem.gov.uk/Sustainability/Environmnt/Policy/Documents1/16669-ROrespJan.pdf>

little over 0.3 Euros in the UK while in Spain it was about 0.5 Euros, Japan about 0.9 Euros and Germany almost 1 Euro.³

5. On top of the costs of building and running the different types of electricity generators, how much investment in Britain's transmission and distribution networks will different renewable energy sources require compared to other forms of generation? Are the current transmission and distribution systems capable of managing a large share of intermittent renewable electricity generation and, if not, how should they be changed? Are the rules about how we connect capacity to the grid supportive of renewables?

23. Wherever and by whatever means electricity is generated it must be delivered to the market. The transmission and distribution networks of the UK are essentially 1960s and 70s infrastructure and were originally built to take energy from source e.g. coalfield to load. The greater the diversity and distribution of generating plant the greater the need for investment in grid development and increased in-grid management costs. The significant sources of renewable energy tend to be remote from major demand centres and grid access points, thus requiring heavy investment in EHV grid extensions and consequential delays to connection. New technology and adaptation will be required for multi-directional flows of power in HV distribution systems where renewables are closer to load centres.

24. The network challenges for renewables are set out below. Each renewable generation technology will bring with it different network configurations and challenges.

Immediate term (1-3 years)

Significant onshore wind connection with other technologies providing limited immediate challenge.

Medium term (3-10 years)

Offshore wind and increasingly distributed technologies

Longer term (over 10 years)

Distributed technologies

Wave/tidal, photovoltaics, micro-GTs, fuel cells and energy storage

25. It is crucial that decisions for investment in the grid infrastructure are made timeously to lead the connection of renewable generation technologies and ensure coordination of construction activities to avoid stranded assets.

26. As an illustration of transmission line upgrade costs, the proposed route for the 400kV overhead electricity transmission line to replace the existing 132kV transmission line between Beaulay and Denny in Scotland has a projected investment of circa £340m.

³ IEA energy R&D database (Euros based on 2005 prices)

27. Active management of the network will be required and Ofgem has been quite far-sighted by creating a range of incentives for further development and application, such as the Innovation Funding Incentive (IFI) and Registered Power Zones (RPZ) programmes. Short term difficulties in the areas of integration and network management are being solved through this route. There is on-going R&D activity in the electrical network technology field, including power electronics and active network management systems. University departments working in these fields are probably the principal repositories of expertise since the dismantling of the research base of the power utilities in the previous decades. The main concerns in this area surround the distribution system, particularly in light of increasing levels of distributed generation, which is generation connected directly to the distribution network. It is likely that small scale and distributed generation will become significant components of generating capacity. Under these circumstances, a “smart” or “intelligent” network able to accept distributed generation with multi-directional power flows, and with the flexibility to incorporate new technologies, is a priority.
28. Major research, development and demonstration in energy storage technologies is needed to meet the needs of increasing intermittent renewables in the system and to balance supply and demand. Pumped storage hydroelectricity is the only proven large scale energy storage mechanism and has been operating for decades using a relatively simple principle. Pumped storage offers a crucial back-up facility at periods of high demand due to its flexibility and could be used to store power from intermittent generators at periods of low demand. There are a range of alternative energy storage technologies being considered such as flywheels, compressed gas, heat storage and electrochemical technologies.
29. With regard to the ‘rules of connection’, there may be scope for more flexible arrangements for the connection and operation of intermittent sources e.g. wind generation and allow the system operator to accept their output at more appropriate times in relation to the load on the network.

6. How do the external costs of renewable generation of electricity – such as concerns in many affected rural areas that wind farms and extra pylons spoil areas of natural beauty – compare with those of fossil fuels and nuclear power? How should these be measured and compared? Is the planning system striking the right balance between all the different considerations?

30. As we mention above, renewable energy by its nature tends to be produced in relatively smaller quantities and from a much larger number of geographically dispersed sites compared with conventional GW-scale power stations. Also, the significant sources of renewable energy tend to be distant from centres of demand and grid access points, therefore requiring extensive grid extensions. These aspects have implications for the external costs such as the impact on landscape, environment and areas of natural beauty. The RSE’s Full Energy Report⁴ sets out the environmental issues pertaining to the various forms of

⁴ Inquiry into Energy Issues for Scotland (June 2006)

energy generation technologies and we recommend that the Committee takes this into account.

31. With the need for large-scale replacement of electricity generating plant in Scotland and the UK within ten years, decisions on the viable options are urgently needed. The choice between the sources has to be on grounds not only of economic costs but also of public acceptability, of security of supply of the raw fuel, the relative lifetime costs and the overall risk of individual technologies to society and to the environment. In terms of such developments impinging on communities, natural heritage and the environment, perhaps some form of compensation or reparation payment could be developed to ensure that the impact is kept to a minimum and those directly affected can derive direct benefit. As an example, the Shetland Islands receive income from the North Sea oil revenues that has contributed to an improved economic state and infrastructure.
32. We referred to the Beaulieu – Denny overhead link in 5 above and this is understandably meeting fierce opposition. High capacity sub-sea cables down the west (and possibly east) coasts of the UK have been suggested as being more acceptable and more effective. These would require massive investment but without major changes to the grid system renewable energy will be unable to make the contribution necessary to meet the UK's long-term aspirations.
33. Whilst we recognise the importance of upholding the democratic process and enabling public engagement on issues of national importance we also realise that it is crucial that decisions can be taken. We suggest that once adopted, national policy should not be a subject for debate in local public enquiries, which should concentrate on local impacts rather than national need.

7. How do the costs of generating electricity from renewables compare to fossil fuel and nuclear generation? What are the current estimates for the costs of “greener” fossil fuel generation with carbon capture and storage and how do these costs compare to renewable generation? What impact do these various forms of electricity generation have on carbon emissions?

34. In 2006 PB Power published a report entitled ‘Powering the Nation – A review of the costs of generating electricity’⁵ which sets out the costs of electricity generated by the different technologies which are commonly available. We recommend that the Committee consider this report. The report showed that in relation to UK market prices current at that time, there were only a small number of commercially viable technologies:
 - Nuclear
 - Supercritical coal
 - CCGT
35. Although the wholesale price of electricity has increased since the publication of the report we are of the opinion that the above findings are still accurate.

⁵ <http://www.pbworld.co.uk/index.php?doc=528>

36. Onshore wind is now considered to be a mature technology and many commentators believe that it can be economically viable without ROCs.

8. How do the costs and benefits of renewable electricity generation compare to renewables in the other key forms of energy consumption - transport and heating?

37. Much has been made of the potential of renewable supplies of energy for Scotland and the UK, but this has been unduly focussed on electricity with inadequate consideration of other higher energy-use sectors, particularly transport and heating. In Scotland, the Forum for Renewable Energy Development (FREDS) Renewable Heat Group has recently reported⁶ and identified recommendations for the key components of a Scottish renewable heat strategy, including the structure of the market, technologies review and mechanisms for supporting renewable heat. We recommend that the Committee consider the findings of the Report.

9. If the UK is to meet the EU target that by 2020 15% of energy consumed will come from renewables, will most of this come from greater use of renewable sources in electricity generation? If so, why? Should British support for renewables in other countries be allowed to contribute towards meeting the target for the UK?

38. To meet the EU 15% renewable energy target will be a significant challenge. It is important to understand that reductions in the UK's total energy demand, both in terms of demand reduction and improved efficiency, will produce proportional reductions in the renewable contribution required.
39. Industry estimates of the proportion of electricity from renewables, if the UK is to meet the 15% of all energy target set by the EU, vary between 40% and 60%. The focus falls to electricity because fuel substitution for transport is seen as being more difficult to realise within the timeframe. Given that renewables accounted for 4.6% of electricity generated in the UK in 2006⁷, the implications of the target are enormous. These implications include the human resources required and manufacturing capacity available, let alone the costs that the electricity consumer will have to bear. With respect to the question concerning support for overseas projects, there seems to be no reason why the UK should not support renewable projects elsewhere, particularly in the EU, and receive credit for that additional renewable capacity.

⁶ Renewable Heat Group Report 2008: "Scotland's Renewable Heat Strategy: Recommendations to Scottish Ministers"

⁷ UK Energy in Brief July 2007; DBERR

10. How would changes in the cost of carbon – under the European emissions trading scheme – affect the relative costs of renewables and other sources of energy? Would a more effective carbon emissions trading scheme remove the need for special support of renewable energy?

40. The cost of carbon is to a large extent fixed under ETS II. In 2013, an “auction” system is likely to be introduced which may allow a more efficient market in carbon to develop; this could result in carbon prices increasing which, if loaded onto carbon intensive generation, could make renewables and cleaner fossil fuel technologies more financially attractive. Essentially, a higher price for carbon (or for that matter, a higher oil price) would make renewables more competitive.

11. What are the costs and benefits of the present generation of biofuels? Will there be a second generation of biofuels and, if so, what are the estimated costs? What are, or are likely to be, the carbon emission impacts of first and second generation biofuels, and what are the other relevant environmental effects?

41. The current status of knowledge means that cost estimates can be highly variable. Current biofuel (biodiesel, bioethanol) production is proven technology and therefore provides a basis for production of non-fossil transport fuels. The Renewable Transport Fuel Obligation places a requirement on transport fuel suppliers to ensure that 5% of their overall fuel sales is from a renewable source by 2010. The Royal Society of London recently published a comprehensive report⁸ on the science and technology prospects of delivering efficient biofuels for transport in the broader context of environmental protection and sustainability. This report shows that biofuels are potentially an important part of the future although the existing policy frameworks and targets may not result in greenhouse gas reductions and wider environmental and social benefits. It is a very complex picture as different biofuels have widely different environmental, social and economic impacts. Whole cycle analysis is required for the different biofuels to assist in determining these impacts. This is also a domain where decision-making is crucial and the (unintended) consequences have to be recognised e.g. clearing tropical rainforests to grow crops negates the intended future climate benefits. Future biofuels are likely to be produced from a much broader range of feedstocks, including agricultural by-products and domestic vegetable waste. Advances in the conversion process will improve the efficiency of producing biofuels. We urge the Committee to consider the Royal Society of London's Report.

Additional Information and References

In responding to this consultation the Society would like to draw attention to the following Royal Society of Edinburgh responses which are of relevance to this subject:

⁸ Sustainable Biofuels: Prospects and Challenges; January 2008

The Royal Society of Edinburgh, Scotland's National Academy, is Scottish Charity No. SC000470

- The Royal Society of Edinburgh's *Inquiry into Energy Issues for Scotland* (June 2006).
- The Royal Society of Edinburgh's submission to the Select Committee on Science and Technology Inquiry into *Renewable Energy-Generation Technologies* (July 2007).

Any enquiries about this submission and others should be addressed to the RSE's Consultations Officer, Mr William Hardie (email: evidenceadvice@royalsoced.org.uk).

Responses are published on the RSE website (www.royalsoced.org.uk).

June 2008