The Royal Academy of Engineering

The Economics of Renewable Energy

Response from The Royal Academy of Engineering to the Lords Economic Affairs Committee

June 2008

The Royal Academy of Engineering
The Economics of Renewable Energy – Summary of Response

The Royal Academy of Engineering is pleased to respond to the House of Lords Select Committee on Economic Affairs consultation on *The Economics of Renewable Energy*. This is an important topic within the wider field of climate change and energy. Fellows of the Academy with experience and expertise in the area have contributed to this response and a summary of the main points are listed below. The Academy would be happy to provide any additional information, either orally or in writing, that would assist the Committee as they move forward with this inquiry.

- Tackling climate change while maintaining a secure and affordable energy supply requires an integrated and co-ordinated energy policy.

- The EU target of 15% of all energy consumption to be sourced from renewable energy by 2020 is extremely challenging given that the current level is less than 2%.

- Renewable energy cannot be treated in isolation. It must be part of a clear and integrated UK energy policy along with other low-carbon technologies and demand reduction strategies.

- The current expansion of renewable generation will impose strains on the electricity transmission and distribution systems, both in terms of the geographical location of the renewable generators and their likely intermittency.

- Forecasts of the increase of renewable electricity should be treated with caution as predictions do not always translate into reality. The engineering practicalities of delivering such a large increase in renewable power must not be underestimated.

- There must be sufficient investment in education and training to ensure an adequate number of skilled engineers and technicians.

- The UK is lagging behind other EU states on deployment of renewable energy despite its rich resources of wind and marine energy.

- The main barriers to greater deployment of renewable energy are capital costs, the planning system, grid connection and the global procurement chain.

- Feed-in tariffs could make development of renewable energy more attractive by reducing the financial risk that developers are exposed to, giving fledgling renewables industries the confidence to invest, develop and grow.

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?

1. Since the Government's 2006 energy review there has been a number of important developments in energy policy for the UK. In terms of renewable energy, the most pertinent of these was the May 2007 Energy White Paper that led to the Energy and Climate Change Bills, both currently progressing through Parliament. In addition, the Planning White Paper is also relevant as it relates to planning permissions for new energy installations and their grid connections. The European Union (EU) has also agreed in principle binding targets which will impinge on UK policy.

2. Within these various documents there are a number of targets, some of which will be legally binding and some merely aspirational. The Energy White Paper repeated the Government's commitment to the target of 10% of electricity from renewables by 2010 along with an aspiration to double this by 2020. It remains to be seen if the Climate Change Bill, which will enshrine in law a variety of targets associated with climate change, will include targets relating directly to renewable energy.

3. The EU currently has a Proposal for a Directive which aims to establish a binding target of 20% of all energy consumption to be sourced from renewable energy by 2020. Within this directive are targets for each member state to achieve 10% of biofuels in transport and individual targets for renewable energy – the UK's proposed target is 15% by 2020.

4. Both the White Paper and EU targets represent enormous challenges when the current situation is taken into account. In 2006, just over 4% of the UK's electricity came from renewables and overall less than 2% of its energy came from renewables – lower than all other EU states bar Malta and Luxembourg. This is in part owing to the UK having, until recently, an indigenous supply of cheap oil and gas. But given that it also has one of the best natural resources of wind and marine energy it could be argued than progress on renewable energy has not been as rapid as might have been hoped, especially taking into account the current Government's claim to be leading the way in tackling climate change.

5. The main policy mechanism for incentivising growth in renewable energy is the Renewables Obligation (RO). Introduced in 2002, it requires the electricity utilities to source a certain amount of their supply from certified renewable generators. The proportion of supply increases year on year, thus providing a continued form of subsidy for renewable technologies which are still being developed. This scheme has, in general, succeeded in achieving its goals and the Government still expects to reach its target of 10% renewable electricity by 2010. It does, however, tend to favour technologies that are more developed and thus less mature technologies do not benefit as much as hoped – a situation which becomes increasingly acute. As a result, for example, much of the recent increase in renewable electricity has come from on-shore wind while marine technologies have not advanced as quickly despite the UK's abundant supply of wave and tidal energy. Consequently, the RO system is in the process of being amended in order to take into account the relative levels of maturity of different renewable technologies. A banding approach has been proposed and is likely to be adopted that will favour less mature technologies such as wave, tidal and

solar photovoltaics. Regardless of any amendments, the Government remains committed to its existing target of RO levels rising to 15.4% by 2015/16, with the possibility of that increasing to 20% given sufficiently rapid growth.

6. In addition to the RO mechanism, the Government has also introduced the Renewable Transport Fuel Obligation (RTFO) which will require that 5% of all vehicle fuel to be supplied from sustainable renewable sources by 2010. This comes into force in April of this year and represents one of the first mechanisms to reduce emissions from the transport sector – where carbon emissions have continued to rise in recent years. There are however, concerns over the sustainability and carbon life cycle of biofuels and their effect on world food prices.

7. Overall, renewable energy in the UK is making progress but is lagging a long way behind our European neighbours. Countries such as Germany, Denmark, Spain and Portugal have all attained a considerably higher proportion of energy from renewable sources. This has been achieved through a variety of economic and regulatory measures. Feed-in tariffs have been particularly successful in Germany, giving the fledgling renewables industry the confidence to invest, develop and grow.

8. Over the coming years, a number of major projects will be needed alongside the more gradual expansion of the renewables sector. The wind and marine resource in the UK would make this possible, but recent developments suggest that progress may in reality be more difficult. The rejection of the Lewis wind farm and the withdrawal of Shell from the London Array project demonstrate that large wind farms, both on- and off-shore, still face an uphill struggle both in terms of planning approval and finance. In addition, the Severn Estuary could potentially provide a significant amount of predictable renewable energy through a tidal barrage scheme – but despite over a century of feasibility studies and proposals, the barrage is no nearer being built.

9. There is much work to be done in the UK if we are to fulfil our promises to lead the world in tackling climate change. The targets that have been set are extremely challenging but meeting them will ultimately provide us with secure, low-carbon energy. This must be strongly encouraged by the Government in as clear and coordinated a way as possible.

<u>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?</u>

10. One of the main barriers facing most forms of renewable energy is the capital cost of installation. Unlike the traditional thermal forms of generation where fuel costs represent a significant proportion of costs, renewables such as wind, marine or solar require no fuel but are more expensive to install initially. The exception to this is biomass and energy from waste, in which case renewable fuels often compete directly with hydrocarbons.

11. The high capital costs affect both large and small installations. At national grid level, a large renewable scheme such as the Severn Tidal Barrage requires capital expenditure far in excess of a typical gas fired power plant. Once installed, it would provide low-carbon, secure and predictable electricity but the level of investment needed is one of the main reasons the scheme has never gone ahead.

12. This problem is often mirrored at the small scale. Even renewable technologies at the domestic scale such as solar water heating, which would eventually pay back any initial capital outlay through fuel savings, can be prohibitively expensive to install.

13. At the national scale, another serious barrier for renewable power is connection to the grid system. With much of the best renewable energy resource occurring a long way from where the power is needed, expensive new grid connections are necessary. For example, the west coast of Scotland has one of Europe's best wind energy resources but is a long way from the south east of England where the highest electricity demand is located.

14. Gaining planning permission for renewable energy projects is also a major barrier. The recent failure of the proposed Lewis wind farm is a case in point and demonstrates that the Government's assumptions on the future growth of renewables may not always be well founded if proposed projects fail to be built through lack of planning permission. It is hoped that the Planning Bill currently proceeding through Parliament will help alleviate some of the current difficulties and give both industry and Government greater certainty going forward.

15. Another barrier results from the global demand for commercially viable technology to combat climate change. This results in strains on the procurement chains which can slow the rate at which a technology can be installed. This is currently felt most acutely with wind turbines where world shortages have led to higher prices for the turbines coupled with long lead times. This situation is liable to be duplicated for other forms of renewable technologies as they mature. It demonstrates that even when a technology is commercially viable, the engineering practicalities of large scale deployment can still present barriers.

16. Thus, global procurement chains can limit the rate at which renewable energy can be integrated into the UK electricity system. For intermittent sources such as wind, wave and solar there is also a limit as to how much can ultimately be absorbed into the national power system. While it is untrue that every MW of intermittent source needs to be backed up with an equal level of thermal generation, a certain level of back up is necessary to cope with variations in supply and demand. The level of back up increases as the proportion of intermittent electricity goes up. This results in external costs and negates some of the carbon savings, however, international experience and research suggests that these effects are manageable for up to 20% of intermittent supply[1]. The more diverse and dispersed the renewables the better as this can provide contingencies for particularly uncommon weather events, although, it should be noted that levelling and reducing demand is also important and as the proportion of renewables increases a method of storing the energy may become crucial.

<u>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?</u>

17. Technological advances will make renewables cheaper. This will be as a result of experience gained through R&D, new materials (particularly in solar PV) and economies of scale - as has been seen in on-shore wind over the last 5 years. However, owing to the barriers detailed in the answer to the previous question, renewables will still require Government support throughout the whole innovation

---

[1] UKERC (2006) The Costs and Impacts of Intermittency, UK Energy Research Centre,

chain from early research to full commercial implementation if they are to help decarbonise UK society.

<u>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?</u>

18. The Government already has a number of mechanisms for encouraging investment in renewable technologies, particularly renewable electricity generation, such as the Renewables Obligation and the Road Transport Fuel Obligation. In addition to these supply obligations, Research, Development and Deployment (RD&D) is being encouraged through the Energy Technology Institute and the Carbon Trust.

19. The Renewables Obligation and Renewable Obligation Certificate (ROC) system was originally designed to be technology blind and offered the same level of financial incentive per kWh of renewable electricity generated, regardless of the technology. It is now recognised that the system favoured above all others the most mature and lowest cost technology, on-shore wind. Proposals are now in place to band the financial incentives offered by the ROC system according to the maturity of the technology involved and this should help to bring wave and tidal stream generating technologies on line.

20. While the RD&D support through the Energy Technology Institute and Carbon Trust, and the support to the generator through the Renewables Obligation do cover both the technology development and its deployment, there is still a real likelihood that the UK will fail to meet its current targets for renewable electricity generation and this is for a number of reasons, some of which are beyond the Governments control.

21. The Renewables Obligation has provided stability over time for the renewable electricity generator market and the industry understands the need to introduce banding for technologies of different market maturity. However, because the ROCs are tradable and generators rely on the wholesale price of electricity as well as the ROCs, developers are still exposed to a high level of price risk. Gas powered electricity generation is usually the price fixer within the electricity market (occasionally coal when fuel prices dictate) because of its dominant position. Consequently gas powered generators can generally pass any short term fluctuations in fuel prices through to the consumer, meaning that renewable generators are directly exposed to an element of gas price risk even though they do not use the fuel. In a number of Continental electricity markets, feed-in tariffs, giving a fixed and guaranteed price for every kWh generated, reduce or transfer this price risk element.

22. The majority of the UK's renewable electricity targets are likely to be met through on-shore and off-shore wind developments by virtue of their market maturity compared to other technologies. However, serious supply chain constraints exist in the wind turbine manufacturing sector. It must be recognised that all energy generator manufacturers now operate in a highly international market and when demand for products such as wind turbines is high, the price will correspondingly rise.

23. Further down the wind turbine supply chain there are issues surrounding competition with other industries for the supply of large, high quality, castings and gearboxes, manufacturers of which can sell into other cyclical industries such as ship building, possibly at higher profit margins.

24. A complication of the wind turbine manufacturers having already full order books is a reluctance among some to invest in the high performance engineering required to ensure the levels of operability required for off-shore deployment. Extremely high levels of operability are required because operators cannot guarantee access to off-shore turbines to carry out maintenance. They are unwilling to lose the use of a turbine for a trivial mechanical or electronic failure if denied access to fix it for long periods of time due to weather conditions. However, if the manufacturer can maintain a full order book without meeting this standard there is no incentive to do so.

25. These industry based barriers to faster deployment of renewables cannot be overcome simply by use of economic instruments based on rewarding the generator exclusively.

<u>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?</u>

26. Investment in the GB electricity transmission system has been cyclical in the past with the last major tranche of investment occurring in the 1970s. The current system has been designed with centralised generation assets in mind, but this is not to say that the system cannot cope with a degree of decentralised generation in its current configuration.

27. The current expansion of renewable generation will, however, impose strains on the electricity transmission and distribution systems, both in terms of the geographical location of the renewable generators and their likely intermittency.

28. There is already a flow of power from Scotland and the North to the South of the UK. Because of geography and historical decisions, the Scottish and English grids are substantially separate with two interconnectors handling a North - South flow of power. Conditions in Scotland are favourable for development of substantial amounts of on-shore wind power, so, planning processes not withstanding, the flow of power from North to South is likely to increase. The North - South flow of power from Scotland to England will be moderated by the planned closure of Hunterston B and Torness nuclear power plants in 2011 and 2023 respectively. Current Scottish planning policy suggests that these stations are unlikely to be replaced with new nuclear build, but ambitious Scottish targets for additional renewables, particularly wind, will mean that the interconnectors role will be of added importance to maintain grid stability in Scotland as well as for large scale power transfer. Investment in further interconnector capacity between Scotland and England is therefore of high strategic importance.

29. The Government expects the majority of its renewable energy targets to be met by off-shore wind. Providing grid connection for off-shore wind projects is

expensive and even when factored into the planning of a project is still fraught with planning uncertainties. An example of this was the denial of planning permission for a sub-station at Cleve Hill for the London Array by Swale Borough Council in June 2006, overturned on appeal in August 2007.

30. Although planning processes are being streamlined courtesy of the Planning White Paper of May 2007, there will remain a “chicken and egg” situation with regard to provision of grid access for new projects. The cost of providing grid access to remote locations and the low rate at which planning consents are converted to active wind farms means that grid connection cannot be provided to sites speculatively. The high number of proposed sites also imposes logistical problems for the grid operator in providing connections as quickly as many developers would like.

<u>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?</u>

31. Each form of renewable energy will have its own associated external costs, although there may be a certain amount of overlap. Below is a summary of these costs for each of the main types of renewable energy.

32. <u>Wind</u>: The impact of on-shore wind farms on the environment is still being assessed. Clearly, their manufacture and installation will result in the expenditure of energy and hence carbon emissions. This can be particularly acute if the turbines displace peat bogs which are very effective carbon sinks. Overall, it would appear that, in most cases, the carbon emitted by wind farms is recouped relatively quickly. In the case of off-shore wind farms there are fewer examples from which to gather data. The increased complexity of installation will necessarily result in greater carbon emissions, but the expected increase in efficiency should counteract this. As more off-shore turbines are installed a more informed picture will emerge, although it must be remembered that variations in the geography will mean that each installation will have its own unique characteristics.

33. On-shore wind has encountered difficulties in gaining planning permission because of local objections on the grounds that they can destroy areas of natural beauty and endanger bird populations. Balancing local concerns against national or global needs is difficult but proposals in the Planning Bill to draw up national policy statements should help clarify this issue.

34. <u>Solar</u>: In the UK, solar photovoltaics (PV) rarely perform efficiently enough to repay the financial investment over the course of their lifetime, particularly in the case of micro domestic installations. As technological advances are made, this situation should improve, but it is unlikely that PV will ever contribute significantly to the UK’s renewable energy targets. Solar water heating systems, however, generally perform much better as the technology is relatively simple and there are few external costs.

35. <u>Marine</u>: Given that marine power technologies are still very much in their infancy, the full environmental effects of their operation are still to be fully assessed. Clearly there will be a correlation between the size of the installation and the degree of impact. Thus large, one-off projects such as a Severn tidal barrage will

have a considerable effect on the ecology and biodiversity of the Severn estuary. This would also be true for large tidal lagoons which would disrupt the currents flowing around them. However, the extent of the impacts are difficult to assess and in some cases may even have associated benefits in terms of flood defences.

36. Wave power is likely to have fewer environmental effects as these devices tend to be less intrusive in terms of disrupting local ecosystems, although due to their low efficiency they are currently unable to provide significant amounts of electricity. With only a handful of pilot schemes operating, the full external costs of wave power are still very much an unknown quantity.

37. Biomass: Much has been written recently concerning the sustainability and carbon life cycle of biomass and liquid biofuels in particular. For example, the Royal Society's report *Sustainable biofuels: prospects and challenges* gives a comprehensive review of these issues. In theory, any energy crop will absorb as much CO_2 while it grows as is released when it is consumed. In practice, the energy used to process and transport the biomass can result in carbon emissions which render the biofuel almost pointless in terms of carbon savings. In addition, replacing indigenous species with single energy crops, such as oil palms replacing rain forest, can lead to soil degradation which is ultimately unsustainable and results in the loss of crucial carbon sinks.

38. Besides sustainability and life cycle concerns, the recent expanse in the biofuels market has also led to financial and social concerns. Global free market regulations mean that it is difficult to restrict any specific biofuel even if it is known to be unsustainable. This has resulted in large agricultural businesses moving into the biofuels market at the expense of smaller, local farmers to the detriment of local economies.

39. In general, all forms of energy generation, be they renewable, nuclear or fossil fuel, will incur external costs to society and the environment. Accurately assessing the full life cycle in terms of greenhouse gases as well as their overall sustainability and social impact is notoriously difficult. The Government must continue to support research in this field and take account of international best practice when developing its energy strategy.

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?

40. The cost of generating electricity is notoriously difficult to estimate as many aspects are covered by commercial sensitivities. A simple comparative approach allowing the calculation of indicative costs was developed by the Royal Academy of Engineering in 2003 and updated by PB Power in 2006, taking into account fluctuations in fuel prices and introducing other sensitivities such as discount rates, carbon prices and utilisation rates.

41. It should be remembered that the costs of generating electricity from particular technologies are only one influence on the price of electricity that consumers pay and do not dictate it. In general, one technology at any particular time, through dominant market position, will be the price maker in the market. In recent years in the UK electricity market this has been gas powered generation and has led to a

situation where gas powered generators can, in effect, pass on their fuel price risks directly to the consumer, meaning that even a wind powered generator, who has no exposure to gas prices in their operating costs, is exposed to gas price risk because it directly affects the price the wind generator can get for the units of electricity generated.

42. The costs presented in the figure below are based on PB Power's updated calculation of June 2006[2] and as such do not reflect the recent increases in the price of oil and gas. While they allow a broad brush comparison of cost of generating electricity from differing technologies, the actual costs vary on a project by project basis.

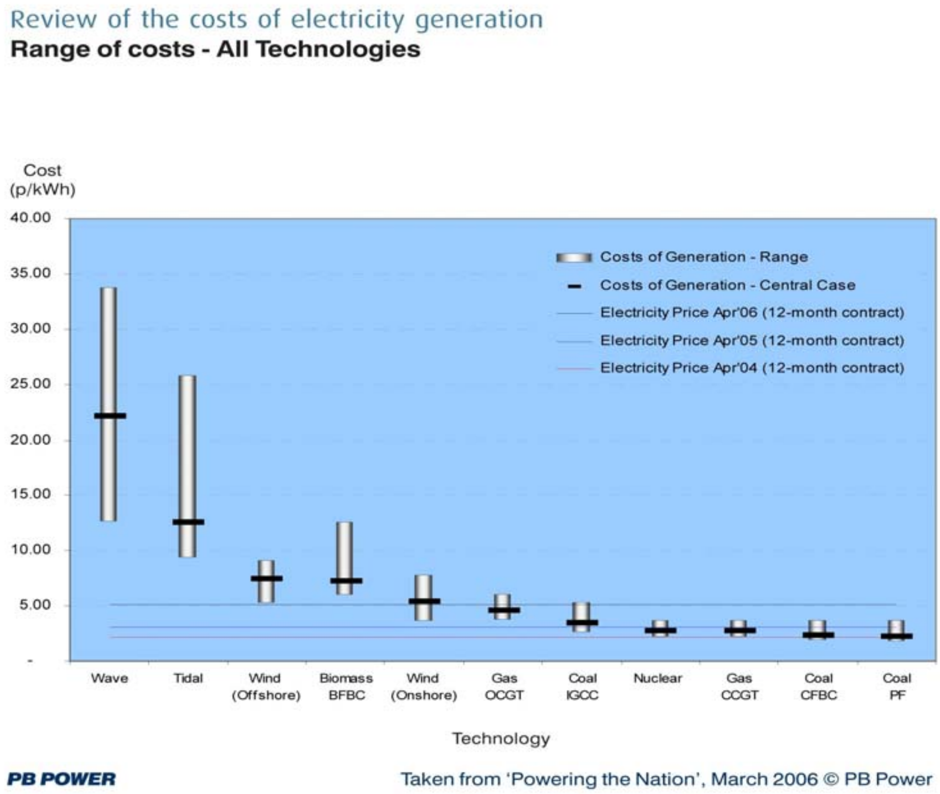

Figure 1 Costs of electricity generation calculated in March 2006

<u>How do the costs and benefits of renewable electricity generation compare to renewables in the other key forms of energy consumption - transport and heating?</u>

43. The main aim of energy policy in the UK is to maintain a secure and affordable energy supply while simultaneously reducing emissions of greenhouse gases. Domestic heating and transport play just as significant a role in this as electricity generation and as such cannot be ignored. Renewable energy can contribute to the goals across all sectors but it must not be forgotten that demand reduction and other forms of low-carbon energy are equally as important.

44. In domestic heating, renewable energy in the form of biomass boilers and solar water heating can be cost-effective and provide significant benefits in terms of carbon savings and sustainability. Geothermal energy may also make a contribution in the future if given support. However, it is often the case that demand reduction measures such as better insulation and passive solar heating

[2] Powering the Nation, A review of the costs of generating electricity, PB Power, June 2006

from south facing windows is equally cost-effective. Other technologies such as heat pumps and district heating systems can also help reduce carbon emissions but these will not contribute to the UK's renewable energy targets, thus highlighting potential conflicts within the UK's overall energy strategy.

45. Transport has proved to be a particularly difficult sector to deal with as there are few alternatives to the liquid fossil fuels on which it currently relies. Renewable biofuels can make a contribution but there are increasing concerns surrounding these which are discussed elsewhere in this response. Plug-in electric vehicles are becoming a more viable alternative, especially as advances are made in battery technology. However, if they are to make a contribution to lowering transport's carbon emissions they will require the electricity to be supplied by low-carbon forms of generation. The same would be true for hydrogen vehicles as the hydrogen would need to be produced by low-carbon energy, otherwise the emissions would simply be transferred to a different sector. Thus, it may be possible to utilise renewable electricity generation in the transport sector but the relative merits of doing so in terms of cost are difficult to assess. In addition, it should again be noted that other measures such as increasing fuel efficiency and changing personal behaviour can also be effective at reducing carbon emissions from transport.

46. What this does emphasise is the importance of developing an integrated energy policy across all sectors of the economy. Renewable energy cannot be treated in isolation and in the long-term should not be artificially favoured over other emissions reducing technologies or strategies simply to meet targets.

<u>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?</u>

46. It is forecast that most of the growth in renewables over the next decade and beyond will come from wind power, both on- and off-shore. The main reason for this is that on-shore wind is the most mature of the various renewable technologies and the experience gained from on-shore wind, coupled with increased load factors expected off-shore, should encourage the growth of off-shore wind farms. This growth would seem sensible in the light of the UK's natural abundance of wind energy.

47. It is also possible that tidal energy could provide a significant amount of renewable electricity if large projects in the Severn estuary or the Mersey are undertaken, although these may not come on line in time for the 2020 targets.

48. Biomass will continue to provide a large proportion of our renewable energy in heat, transport and electricity. Co-firing of biomass will be particularly valuable if fossil fuel prices continue to rise and emissions from power stations are increasingly restricted. It may ultimately be especially beneficial if coupled with carbon capture and storage systems in the future.

49. A note of caution is needed regarding forecasts of the increase of renewable electricity as predictions do not always translate into reality. The engineering practicalities of delivering such a large increase in renewable power must not be underestimated. Not only are there barriers in terms of the planning system, grid connections and the global procurement chain, there will also be a shortage of

skilled engineers without adequate levels of investment in education and training .

50. The question of whether UK support for overseas projects should contribute to meeting targets is difficult. On one hand, climate change is a global problem and the most effective and economic solutions should be sought regardless of their geographic location. On the other hand, it is essential that the UK leads the way in decarbonising its own society while maintaining economic stability; this will not happen if all its efforts are carried out abroad. It would therefore seem sensible that the UK is permitted a limited amount of overseas credits but that the bulk of the target is met by UK based renewables. Concerns over the accountability and additionality of overseas projects must also be addressed by Government along with international partners.

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?

51. A strong carbon market would help renewables compete in the market with other forms of energy generation. What is needed is not just a relatively high price of carbon but a robust market which would allow industry to feel confident enough to make long term investments in low-carbon energy.

52. All markets are susceptible to fluctuations (as has been seen recently in the oil and gas markets) but the EU Emissions Trading Scheme in its first two phases has not performed as well as it was hoped. This was in part due to the fact that it was the first mandatory scheme of its type and teething problems were to be expected. As it moves into its third phase it should perform better and with a number of other trading schemes starting up around the world it is likely that the price of carbon will become more stable.

53. Ultimately this will help renewables but it must be remembered that trading schemes will make all low-carbon energy cheaper in relation to traditional fossil fuels. Given that the aim of trading schemes is to cap emissions of carbon this is as it should be but renewables will then be competing with other technologies such as nuclear power and carbon capture and storage which will also become relatively cheaper.

54. Additional subsidies may still be required for technologies in the early stage of development but in the long run any technology should be able to compete in the market on level terms with all the alternatives.

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?

55. The basic advantage of liquid biofuels over their fossil fuel counterparts is that, while both emit carbon dioxide when burnt in an engine, the biofuel absorbs an equivalent amount of CO_2 as the plants used in its production are grown. In theory, this means that over their life cycle biofuels are carbon neutral. In practice however, once agricultural methods, processing and transportation are taken into account, (i.e. a more detailed life cycle analysis), the carbon mitigation benefits of

various biofuels can differ greatly with some proving to be little better than fossil fuels.

56. Another perceived benefit of biofuels is with regard to security of supply. Rather than using up irreplaceable fossil fuels which are often sourced from politically unstable regions, biofuels can be grown in any agricultural area and the crops are sustainable. Again, the reality of the situation is somewhat more complicated. Biofuels can indeed replace fossil fuels as a source of energy, but in doing so affect agriculture and land-use. If land currently used to grow food crops is replaced with energy crops the price of food can increase – as occurred with world corn prices following US subsidies for bioethanol. If, on the other hand, non-agricultural land is converted to energy crops important carbon sinks can be adversely affected – as can be seen in the case of Indonesian rain forest being cut down to make way for palm oil plantations. This can result in any carbon savings being totally nullified along with other serious negative effects, such as decreased biodiversity.

57. One aspect where biofuels do have an advantage, on the face of it, is in replacing liquid fossil fuels in transport. Attempts to decarbonise the transport sector have always proved particularly problematic. Any advances in terms of fuel efficiency have been largely offset by weight increases due to higher vehicle specifications as well as societies becoming ever more mobile. There are possible fuel alternatives such as hydrogen and electric hybrids, but these would require a radical overhaul of both road vehicles and the associated infrastructure and are a long way off being in any way viable for sea or air transport. Biofuels, on the other hand, can simply be added to existing liquid fossil fuels and at low percentages require little or no changes to either the vehicles or the fuel infrastructure.

58. It is likely that the ease of adding biofuels to road transport fuel is one of the main reasons that governments here, in Europe and further a field have introduced targets for their introduction. However, as noted above, a more detailed analysis of their carbon life cycle, issues of land-use and negative social and environmental effects can reveal that, in reality, the situation is often less than favourable. The main problem with the first generation of liquid biofuels is the amount of energy needed to process the raw material and the relatively low yield per hectare of land. Whether producing bioethanol or biodiesel, very little of the plant is actually converted into the fuel. Most of the plant is unable to be broken down and is therefore discarded. A second generation of biofuels is expected which will be able to utilise the tougher lingnocellulosic part of the plant and hence increase yields. While this would be an improvement, the question does need to be asked if processing biomass into liquid biofuels is the best approach when the whole plant can easily be broken down by burning either at large scale as co-firing in power plants or small scale in domestic boilers or CHP plants. Indeed, if carbon mitigation is the main driver it has also been shown that alternative approaches such as reforestation can be even more effective.

59. What the above points do highlight is the fact that even though a certain technology can seem to offer a number of advantages, governments should be wary of introducing sweeping regulations and subsidies before the full picture is understood. Biofuels can certainly offer clear benefits in certain circumstances. In particular, local projects and ones using waste products can be very effective. As is often the case, care needs to be taken when dealing with such a complex issue as climate change and energy.

Submitted by:
Mr P Greenish CBE
Chief Executive
The Royal Academy of Engineering
3 Charlton House Terrace
London SW1Y 5DG

Prepared by:
Dr Alan Walker
Policy Advisor