The Royal Society of Edinburgh

Inquiry into Energy Issues for Scotland

Summary Report

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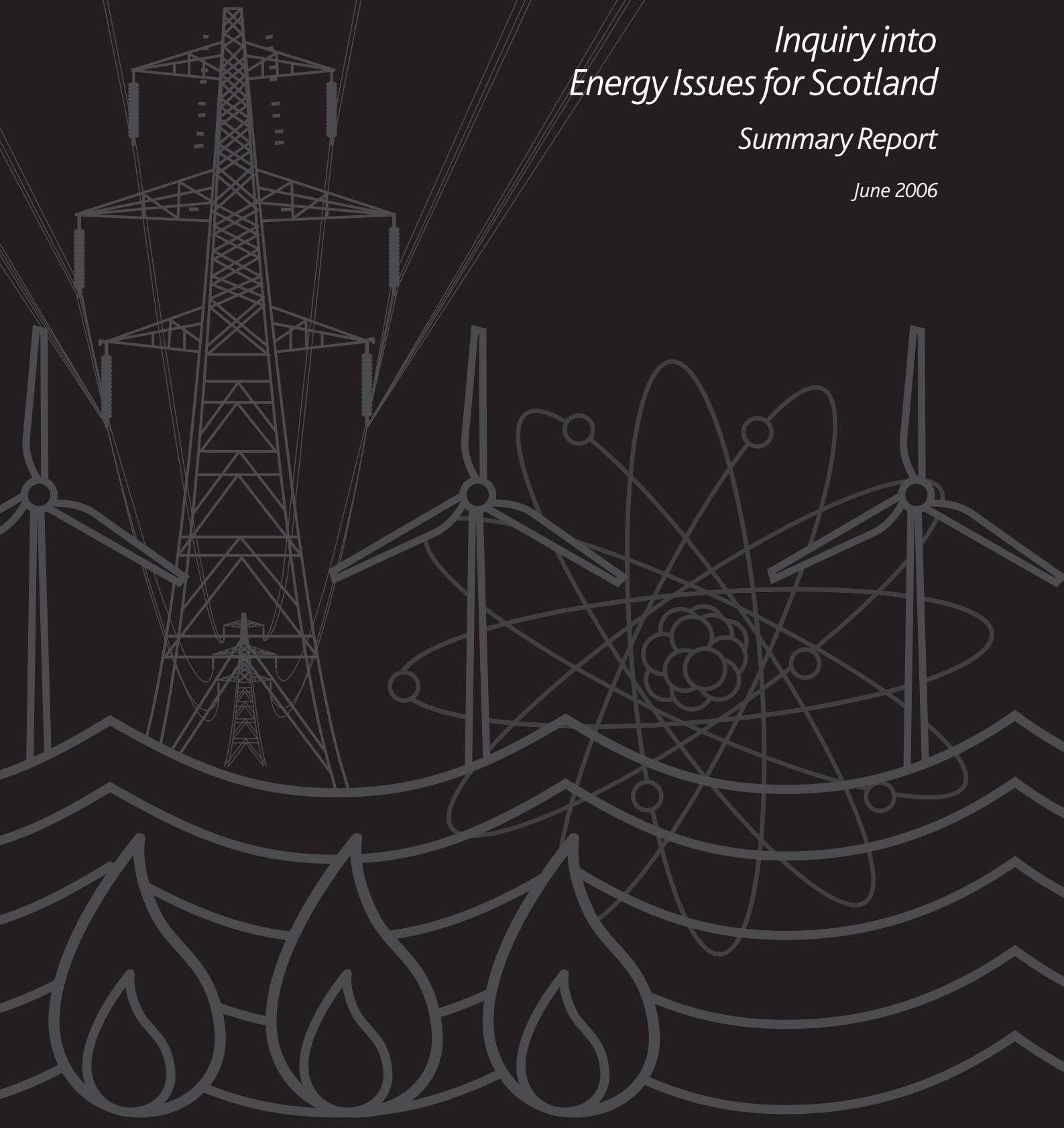

Preface

The Royal Society of Edinburgh, as the National Academy for Scotland, has a Fellowship containing great expertise across all the sciences, technologies, humanities and the arts. The Fellowship is elected from the worlds of academe, public and private service, commerce and industry. As a membership organisation it has no political allegiance nor does it represent any sectoral interest. As such it is uniquely placed to offer informed, independent comment on matters of national interest.

In May 2005, the Council of the RSE established a Committee of Inquiry into Energy Issues for Scotland. The Committee was given a broad remit to consider all aspects of energy supply and demand but also to examine relevant economic, environmental and social matters. I believe that this represents the most comprehensive study of energy issues ever undertaken in Scotland.

Energy issues have become a matter of global concern and in Scotland there has been a rapid escalation of public and political interest. We are at a turning point in our history as we move from being a self-sufficient exporter of energy to a possible dependence on imported energy from an increasingly competitive World.

It is my hope that this Report will stimulate and inform public debate on the issues and provide an evidential base upon which policy can be based and decisions taken.

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Energy Issues for Scotland

There are a number of critical issues about the supply of and demand for energy in Scotland over the next two decades. Disagreement on the facts, the solutions, and what needs to be done is rife. Scotland is facing a reduction in North Sea oil and gas production at the same time as its coal and nuclear electricity generating plants are approaching the end of their economic life. Within ten years Scotland will lose about 30% of its electricity generating capacity from large plants and within twenty five years is likely to lose it all. At the same time, energy and environment targets have been set for 2020. As a result, Scotland is anxious to develop its rich resources of renewable energy and the Scottish Executive has signalled that it desires to contribute fully to the reduction of greenhouse gas emissions as part of the global programme to address the issue of climate change.

The strategic aim should be for a secure, competitive, socially equitable and low carbon emissions supply of energy for Scotland.

This will require energy from a diversity of fuels, countries, and technologies, helping Scotland to be competitive in global markets, with all sections of society having access to energy at a price they can afford, and using technology with the lowest greenhouse gas emissions throughout their life cycle. **Our report argues that achieving this strategic aim is the critically important issue. This requires a comprehensive and integrated strategy on energy and four components of action:**

(1) increasing the efficient use of energy;

(2) using cleaner energy sources;

(3) researching and developing new technologies to benefit Scotland; and

(4) implementing more effective measures to improve market operation.

For all of these aspirations to be achieved, Scotland has to think in a global context and act locally, using the natural resources at its disposal in a manner which provides social, economic and environmental benefits.

Time is not on our side. Without early decisions by government and by the market, there will be problems of energy supply. These could be socially disruptive and economically damaging. There is no one, single solution. There are many opportunities for Scotland based on a combination of its natural energy resources and its intellectual and technological prowess. This report is a contribution to the issues. We hope that its contents will better inform the debate and the decisions that need to be taken through a process of engagement and dialogue by all interests. Without it, polarisation of positions will continue.

Background

Energy demand is predicted to double between 2000 and 2050 as a result of increases in global population and in the growth of global Gross Domestic Product. The future demand for and supply of energy has, therefore, become an increasingly important issue for countries worldwide. So it is for Scotland with a predicted increase of 50% in energy demand.

There are three principal drivers of future energy policy:

Security of supply

North Sea oil and gas production is in decline. Ageing coal and nuclear electricity generating plants are reaching the end of their economic life. All of Scotland's large-scale electricity generating plant will close within 25 years. If present trends continue, the United Kingdom and Scotland will, by 2020, be largely dependent on imported gas, much from politically unpredictable sources, and probably in an environment of strongly increasing demand competition and rising price. There are, therefore, major uncertainties about the future security of energy supply.

Emissions

There is clear evidence linking climate change to the content of greenhouse gases in the atmosphere. It is widely accepted that human activity, including the combustion of fossil fuels, contributes to greenhouse gases in the atmosphere. The UK has set a target of reducing its carbon emissions by 60% by 2050. To achieve this target

energy policy must, therefore, include a framework that delivers a more efficient use of energy, the use of cleaner energy sources, and research and development for new technologies that can advance cleaner and more efficient energy supply and use. We will still be reliant on a significant contribution from fossil fuels as one part of a diverse energy supply, but we will have to find ways to reduce the net carbon emissions from the use of such fuels.

Price

The impact of energy prices has changed dramatically since the privatisation and liberalisation of the electricity market and the establishment of the regulator in the UK. For the future, therefore, price will remain an important driver. A new energy policy, that also prioritises security of supply and emissions reduction, must be developed in a way that neither undermines our relative economic competitiveness, nor imposes excessive energy costs on those unable to bear them.

With the imminence of an "energy gap" in Scotland, the long lead-time required to plan, invest in and implement changes in electricity generation and its associated transmission, and the imperative to reduce global emissions, speedy decisions are needed. In the present environment of a liberalised UK market, many of the key investment decisions will be made by private enterprises. The role of government should be to set the long-term context with unambiguous objectives and relatively stable economic instruments and regulations. These will enable confident investment decisions to be made, and an expectation that the operation of a competitive market will deliver on price.

An ideal scenario would be one in which companies were free to exploit a large number of generation technologies and deploy them in ways that optimised security, emissions reduction and price. However, there are major issues of public acceptability that militate against such a straightforward approach. In recent years, governments in the UK and elsewhere have found it increasingly difficult to implement policies for new technologies in many fields. This is primarily because of their failure to engage with public concerns, and has led to a perennial failure to create acceptable public policy. The torrent of letters to Scottish newspapers exemplifies the problem. Many firmly reject specific technologies, others advocate a single technological solution, and relatively few recognise that difficult decisions will almost certainly have to be made that do not command complete public support.

It is vital to recognise the need to inform and engage with the public on energy matters. And it is especially important to strengthen the education of younger generations who will have to live with the consequences of current decisions.

The spectrum of major energy technologies from which choices must be made does not offer easy options for Scotland or the UK. The redevelopment of coal or nuclear power, the spread of wind turbines, the extension of hydroelectric generation, the large scale development of biofuels, the development of tidal or wave generation, and the use of hydrogen as a compact and energetic vector variously pose problems of health risk, environmental damage, climatic impact or technological uncertainty. The more options that are ruled out because of objections by this or that group, the more difficult it will be to devise a policy that will meet the strategic aim and objectives set out above. As a consequence, any policy development is likely to be contentious. A key question for the Scottish Executive is how to manage a public debate which is based on sound evidence and results in genuine reflection of overall public attitudes and values without being excessively skewed by the activities of individual pressure groups.

It was with these considerations in mind that the Council of the Royal Society of Edinburgh commissioned a report into energy issues for Scotland to inform the ongoing debate from a broad, scientific and technical perspective. The dramatic increase in political and public interest in energy issues highlights the timeliness of the Inquiry.

The Inquiry was launched in May 2005 with a remit to:

- Review all options for energy supply in Scotland taking account of the UK, European and global energy setting.
- Review all sectors of energy demand in Scotland.
- Consider the economic, environmental and social impact of energy supply and demand.
- Carry out the Inquiry for a time frame to 2050.
- Encourage public debate of the issues and provide an evidential base to inform that debate.

The Inquiry was carried out by a Committee of independent individuals with a wide knowledge of Scotland and energy issues. Given the breadth of the remit, no manageable committee could have contained all the necessary expertise, thus the Committee consulted widely. It met and took evidence from nearly a hundred expert witnesses, received nearly two hundred written submissions and held meetings in Lewis, Orkney, Shetland, Inverness, Aberdeen, Glasgow, Edinburgh and London. In addition, a delegation visited Finland to observe its approach to energy issues.

Scope of report

Our report sets the global, UK and Scottish contexts for energy and describes UK and Scottish policy positions and instruments. It proposes a specific aim and objectives for energy policy for Scotland and assesses the technological and policy options available in pursuing them. It recognises, however, that the specific choices that need to be made will depend upon a political process that the Scottish Executive must promote.

Opportunities for improvements in energy efficiency are analysed and recommendations made. The main energy-using sectors in Scotland are transport, domestic heating and electricity. A review of the present position is presented and proposals for improvements are made. We identify the opportunities for Scotland in research and development, and specific opportunities with respect to low carbon energy technologies. We make proposals for the engagement of the public in decisions on energy. We conclude by assessing the decisions necessary by the UK and Scottish Governments and by Local Councils, as well as industry on short and longer time scales, including specific recommendations on the modification of existing and the development of new instruments.

The full Report and Appendices containing data and argumentation will be made available simultaneously with this Summary Report as a web-based version at *www.royalsoced.org.uk*. A hard copy version of the full Report will be published later.

This document summarises the key issues that emerged from the Inquiry, and presents our principal conclusions and recommendations.

Government Strategy, Policy and Action

From our perspective, the key issue for the UK government is that it should provide the framework, with the associated regulations and incentives, within which long-term investment decisions can be made and the needs of the consumers met.

We support the general thrust of current UK Government policy as stated in the Energy White Paper 2003. This seeks to meet a range of objectives, principally security of supply to consumers, reduction in carbon emissions as a contribution to combating global climate change, and reduction in the number of households that are in fuel poverty.

Energy policy and many of the mechanisms to implement it are matters reserved to the UK Government. Other mechanisms necessary for policy implementation, such as planning and building regulations, are devolved to the Scottish Executive. We expect the Scottish Executive to promote and protect the interests of Scotland in the development and execution of UK policy. This means that the Scottish Government should work within the UK Government framework, but with the opportunity to tailor approaches to meet Scottish needs and opportunities. It also means that no sensible strategy or implementation mechanisms at the UK or Scottish levels will emerge unless the two legislative authorities work in the closest harmony.

Privatisation of the energy supply industry and liberalisation of the energy market have resulted in the lowering of energy costs to consumers until price rises in 2004. It had the predictable consequence that there was a convergence of supply technology to the lowest cost option: gas. This ‘dash for gas’ had the beneficial effect of reducing carbon emissions as coal-fired generation for electricity was replaced by gas-fired generation in the 1990s. It also built in a future dependence on imported gas supplies. Where gas has replaced nuclear power generation it has led to an increase in carbon emissions. Once this one-time gas for coal replacement was complete, carbon emissions ceased to decline and the Government sought other ways to meet its Kyoto targets. This led Government to intervene in the market with its policy of subsidising renewable power generation, as outlined in its 2003 Energy White Paper.

The UK Government's current 2006 Energy Review is timely, as the 2003 Energy White Paper failed to specify how solutions on key issues, such as the type of electricity generation and the longer term basis for meeting the Kyoto targets, were to be resolved. Since the beginning of our Inquiry, there has been much greater recognition of the energy issues that need to be addressed at the UK level with reviews on many aspects commissioned by the UK Government. Due to the timescales for building nuclear and clean-coal electricity generating plants, the potentially limited contribution from renewables in the short term, and the construction of gas storage facilities, there could be a second 'dash for gas'. This could undermine the achievement of security of supply.

The revised UK Government strategy should explicitly include economic, social and environmental perspectives. It should also have an explicit objective and actions to achieve the strategic aim we propose: **a secure, competitive, socially equitable and low carbon emissions supply of energy**.

From the evidence available to us, there is currently no cohesive and integrated approach to energy at the UK Government level, and there are many initiatives which appear to lack connections or compatibility with other initiatives. The general framework developed by the UK Government needs to have a long-term stability. Only then will investors have the confidence to make decisions that are required to modernise the system of energy generation and supply, and consumers have the confidence that action is being taken to satisfy their energy needs. There is an overriding need, therefore, for a more comprehensive and integrated approach to energy strategy, policy and action. We are concerned when the government fails to take decisions that set the conditions for investment, since this can lead to a reduction in options. A firmer and longer term basis is required; without it, inadequate decisions are likely to be made. These issues should be resolved unambiguously by the UK Government in its 2006 Energy Review.

> **Recommendation 1:** It is essential that decisions are taken by the UK Government by the middle of 2007 to provide a more stable and longer-term policy framework to give greater assurance to the consumer on continuity of energy supply and to give confidence to the providers of energy to make investment decisions.
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> **Recommendation 2:** The UK Government should maintain the energy policy objectives set out in the 2003 White Paper: to ensure an adequate, safe and secure supply of energy, to reduce the emission of greenhouse gases with the setting of unambiguous long-term targets, to promote economic development, and to protect vulnerable sections of the population from the adverse effect of market forces.
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> **Recommendation 3:** The UK Government should periodically review the instruments and targets used for implementing the policy framework to assess their effectiveness in achieving their intended objectives, and to ensure that unintended consequences have not arisen.

The questions on strategy and policy for Scotland are: how should it respond to a probable sharp decline in its electricity generating capacity; what will be the impact of declining oil and gas production on energy availability; what use can it make of its resources of renewable energy (wind, waves, tides and biomass); and what role should it play in the global campaign to reduce greenhouse gas emissions?

In Scotland, there are many policies developed by the Scottish Executive that include aspects of energy, but there are limited explicit links between the many initiatives from different parts of the Scottish Executive and no obvious integrated overall strategy. More effective handling of cross-cutting issues in relation to energy and its links to environmental, economic and social programmes is also needed. The strategy for sustainable development provides the overall envelope within which a more explicit, comprehensive and integrated strategy for energy should be developed. This is an urgent priority. It should guide Scottish Ministers in their decisions on energy. It should also re-assure the public that decisions on all aspects of energy are taken within a clearly articulated framework, rather than in an ad hoc and uncoordinated manner as has been perceived to be the case in the past.

The strategy must include a clear articulation of the objectives of energy policy for Scotland. We propose as the strategic aim: **a secure, competitive, socially equitable and low carbon emissions supply of energy for Scotland.**

There should be four supporting objectives to:

(1) encourage energy efficiency to the benefit of economic development;

(2) ensure that energy availability contributes to improvements in social benefits to Scotland's people;

(3) minimise adverse environmental effects, both locally and globally; and

(4) capitalise on the natural energy resources of Scotland in an economically viable and environmentally sensitive way.

We hope that they will inform the debate and influence the decisions taken.

> **Recommendation 4:** We strongly recommend that the Scottish Executive develops a comprehensive energy strategy, within the boundaries of its powers and responsibilities and in consultation with the UK Government, by the end of 2007. This should embrace specific strategies on energy efficiency, transport, heating, electricity generation and the use of renewables. This should also include an overriding aim of achieving a secure, competitive, socially equitable and low carbon emissions supply of energy, and the four supporting objectives we propose.

We have considered the need for an arms length **Energy Agency for Scotland**. Our reasoning is as follows. There is a public perception of the need for more independent arms-length advice to government and to all who are involved in or have an interest in energy matters affecting Scotland. Decisions within the Scottish Executive appear, in the past, not to have been made within a coherent framework. There are many government incentives on energy and we consider that the potential recipients would welcome their more coordinated and integrated delivery. There is a legitimate need to have independent scrutiny of the energy policies and actions of other parts of the public sector. There is also a need for an independent review of energy technologies to guide decision making. Scotland's input into UK energy matters is critical and a more open and transparent process for developing this would be beneficial. There is an overriding need to have greater effectiveness on energy efficiency. And, finally, there would be benefits to be gained from ensuring that best practice on all aspects of energy supply and use is disseminated to all interests in Scotland. For all of these reasons, we firmly recommend that an Energy Agency for Scotland be established.

We consider that the need for openness and transparency, and the ability to advise government and all relevant interests, requires the proposed agency to be at arms length from government in the form of a Non-Departmental Public Body. To be effective, the body will need to be given broad advisory and executive powers on all aspects of energy by the Scottish Parliament, within the ambit of the devolved powers on energy, and to have effective, independent leadership.

> **Recommendation 5:** The Scottish Executive should seek Parliament's approval for the establishment of an Energy Agency for Scotland as a Non-Departmental Public Body. Its responsibilities should include ability to advise the government and all other interests on all aspects of energy, promotion of energy efficiency, disbursal of all grants and incentives related to energy, independent assessments of technology options and whole lifetime costs, and gathering and disseminating best practice on energy use.

We make a recommendation (10) later for the establishment of an Energy Efficiency Agency for Scotland. If the Scottish Parliament decides to establish an Energy Agency for Scotland, as we recommend, then the Energy Efficiency Agency for Scotland should be subsumed within it.

We are concerned that there are no robust procedures for assessing energy technologies. Many assessments undertaken are not sufficiently objective to inform the decision-making process and to reassure the public that openness and objectivity have been applied in practice. To overcome these problems, a number of developments are necessary. A common methodology should be developed. We identify nine factors that should be used in all future assessments: state of technology, infrastructure requirements, security of supply, carbon benefit, effects on water quality, use of waste produced, costs to the consumer, effects on communities, and effects on natural heritage assets. In addition, the assessments of technologies must take into account the full lifetime costs, and an audit of their carbon effects. The methodology should be applied in an independent manner. For these reasons, we make the following recommendation:

> **Recommendation 6:** A common methodology could and should be developed by the proposed Energy Agency for Scotland to assess the relative merits of energy technologies, using the nine factors identified. It should include full lifetime costs and a carbon audit. Assessments using the methodology should be undertaken independently of specific interests and be open to public scrutiny.

Energy efficiency

Energy efficiency is one of the key elements of our recommended approach on energy for Scotland. We use the short-hand 'energy efficiency' to include reducing energy use, making energy use more effective, and reducing waste in an energy context.

The most effective approach is widespread adoption of best practice. Two practices are most obvious. First, we note the much greater use of combined heat and power in many overseas countries to provide both electricity and heating to the consumer. Serious consideration should be given, for example, to the use of waste heat from industrial processes, including from electricity generating stations. In particular, new plants should be designed to reduce energy loss and link waste energy to a useful purpose.

> **Recommendation 7:** Industry should be persuaded, through economic instruments and approval mechanisms in the statutory planning system, to utilise waste energy, especially heat, for beneficial purposes. In particular, we recommend that all future small thermal generating plants, near to population centres, should have specific arrangements for the use of waste heat.

Second, we note that Scandinavian and German buildings are considerably more energy efficient than those in Scotland. Raising building standards in Scotland to the level in those countries could save approximately 20% of domestic energy consumption. From April 2006, builders in the UK must put in place measures to cut the energy use of residential and commercial properties by 40%. The UK Energy Efficiency Commitment provides the basis for meeting targets, but Ofgem's review shows that the Commitment has not been successful in reaching the targets. The tougher targets we propose, and their more effective implementation, should be introduced through a revised Commitment.

Over the next 50 years, the existing housing stock will need replacement heating sources. It is essential that replacement appliances are significantly more energy efficient and that combined heat and power, irrespective of fuel source, becomes normal practice in communal housing schemes.

It is essential that existing Building Regulations are improved to include higher energy standards and that they are more strictly enforced. We received evidence that modern buildings with stricter Building Regulations were markedly less energy efficient than either older buildings constructed in traditional stone or the council houses that had been regularly upgraded to meet evolving energy standards. We were also told that there are few checks on the actual standards in new buildings and that there are no penalties for energy inefficiencies.

There is evidence from recent European tendering exercises that more energy-efficient buildings need not cost more to build.

> **Recommendation 8:** Local Councils should stimulate more energy efficient housing designs through the Building Regulations system and should substantially improve the enforcement of Building Regulations in relation to energy efficiency.

We note within Scotland a considerable variation in the priority given to energy efficiency by Local Authorities. We commend good practices seen, for example, in Aberdeen applied to Council building stock and in Lerwick to waste management.

The statutory responsibility for promoting energy efficiency lies with the Scottish Executive. There is an urgent need for a more coordinated and effective programme of action on energy efficiency for Scotland. We welcome the announcement that the Scottish Executive is to develop an energy efficiency strategy and consider that this should be a key element in the overall energy strategy (see Recommendation 4).

> **Recommendation 9:** A more comprehensive and integrated package on energy efficiency should be developed at both UK and Scottish levels to reduce the current confusion and increase effectiveness. This should be linked to strengthening the targets and ensuring their achievement under a revised Energy Efficiency Commitment.

We believe a new organisation should be established to champion energy efficiency in Scotland. Our reasoning is as follows. There is a plethora of support schemes with very low uptake that require more effective delivery. Scottish performance is far below what it should be in comparison with many similar European countries.

The mechanisms available, such as the planning and building regulations systems, are not being used effectively. There is also a great deal of good practice in Scotland that is not widely known. If the Scottish Executive rejects our recommendation for the establishment of an Energy Agency for Scotland (Recommendation 5), we specifically recommend the establishment of a Non-Department Public Body, at arms length from government, on energy efficiency: **an Energy Efficiency Agency for Scotland**.

> **Recommendation 10:** The Scottish Executive should seek Parliament's approval for the establishment of an Energy Efficiency Agency for Scotland as a Non-Departmental Public Body. It should have both advisory and executive powers with authority to scrutinise and make recommendations on energy efficiency action in the public sector, disburse incentives for reducing energy use, increasing efficiency and supporting novel initiatives, and for disseminating best practice.

> **Recommendation 11:** The Scottish Executive should require Local Councils to achieve specific and measurable improvements in the efficient use of energy through the town and country planning system and building regulations.

There are financial and other benefits to the suppliers of plant and equipment, owners of property, and the public in the development and use of energy efficiency devices. We strongly support action for improving the efficiency in the use of energy. However, there is a plethora of schemes and a relatively poor take up, especially by small and medium sized enterprises and domestic consumers. Part of the reason for this is that energy efficiency requires behavioural change. We consider that this requires a package of education, information and financial incentive. Educational material to be made available to the public, especially schools, would be a valuable component. We note that information, such as the energy efficiency labels, is now displayed on electrical white goods and cars. We believe that this practice could profitably be extended to cover all energy-using devices and buildings. We also consider that financial incentives and penalties, designed to promote behavioural change, should be introduced. There are a number of possibilities for consideration by the UK and Scottish Governments. Energy efficiency labelling of buildings, linked to an energy efficiency dependent stamp duty and Council Tax band could prove a powerful market incentive for more energy efficient buildings. An energy efficiency dependent VAT system should also be considered.

> **Recommendation 12:** As part of encouraging the change of behaviour needed on energy efficiency, a comprehensive set of measures including education, information and incentives should be developed by the proposed Energy Agency for Scotland (or failing that by the Scottish Executive).

In support of this Recommendation we propose the following actions:

(1) educational resource materials on energy efficiency should be provided to primary and secondary schools through Learning and Teaching Scotland;

(2) an independent assessment should be undertaken to ascertain the causes of failure of energy efficiency schemes as a basis for implementing more cost effective schemes; and

(3) the UK Government should consider financial measures to stimulate changes in behaviour on energy efficiency.

These actions should be taken by the Energy Agency for Scotland.

We consider that the greatest inefficiency in transport is the under utilisation of carrying capacity by private vehicles and by public transport. We believe that measures to benefit high occupancy private vehicles, such as lane preference and variable road charging, should be introduced. Similarly, more flexible public transport fleets would allow smaller vehicles to carry fuller loads during off-peak periods.

> **Recommendation 13:** The UK Government should consider measures, such as the use of lane preference and variable charging systems, to encourage higher occupancy in private vehicles.

> **Recommendation 14:** Bus transport operators should be given greater incentive through the Scottish Executive's current service support mechanism to operate a wider range of vehicle types to cope with variable passenger loads.

Cleaner energy

Currently over 80% of the energy consumed in Scotland is in the form of fossil fuels. As part of their combustion cycle, all emit carbon gases that aggravate the already potentially catastrophic situation with regard to global climate change. In addition, coal raises special concerns in relation to smoke and acid rain. There are three approaches to this: emission control, fuel substitution and fuel efficiency. We have already addressed the question of energy efficiency but note that this has particular relevance to fossil fuels in the reduction of carbon emissions.

(1) Emission control

Every effort must be made to develop technologies for carbon gas capture and storage. There is research expertise in Scotland's industrial and academic base that contributes to these developments. With the continued operation of the Longannet coal-fired electricity generating station, there is an opportunity for industry, government and academia to work together to prove carbon capture and storage technology. Apart from the potential to contribute to Scotland's targets for carbon emissions reduction, the development of such technical skills will have export potential, as coal is likely to remain a major source of the world's energy needs. The technology, although most urgently required for coal combustion, will be applicable to all fossil fuels. We welcome the recent report commissioned by Scottish Enterprise and the Department of Trade and Industry to assess the opportunities for carbon capture and storage.

> **Recommendation 15:** Scottish Enterprise should engage with Scottish Coal, Scottish Power, Matsui-Babcock, the Scottish Universities and other stakeholders, to determine a significant clean coal research and development programme in Scotland.

(2) Fuel substitution

The non-carbon gas emitting fuels are hydro-electricity, renewables (wind, marine and solar power), and nuclear. Biomass and waste are considered as carbon neutral. In addition to reducing carbon emissions, the development of Scotland's many natural renewable sources of energy offer the prospects of local economic benefit and contribute to the diversity and, therefore, security of supply of energy sources.

The variety of technologies and their varying speed of development for the market often create uncertainty for decision-makers and for the public. We recommend that the proposed Energy Agency for Scotland is tasked with providing an on-going energy technology scrutiny and advisory service, in conjunction with the Intermediary Technology Institute Energy (ITI Energy).

> **Recommendation 16:** An energy technology scrutiny and advisory service should be established by the Scottish Executive. Ideally, this should be part of the functions of the proposed Energy Agency for Scotland with ITI Energy.

There are five reasons for encouraging the use of renewable energy sources: the reduction of greenhouse emissions, diversification of supply to increase security, use of a local resource, stimulation of local economic activity, and the contribution to sustainable development. However, it must be recognised that different renewable resources are at different stages of marketability and the uptake of a particular technology will be guided by economic factors, albeit shaped by the government's policy framework.

Scotland has a diversity of renewable energy sources and to date only a small proportion of these are being exploited. We strongly encourage further research, development and demonstration to commercial scale of the various technologies so that Scotland can contribute fully to the UK provision of energy supplied from renewable sources. This approach should bring economic and environmental benefits.

> **Recommendation 17:** The research community, government, ITI Energy and the private sector should work together to provide the financial, intellectual, policy and enterprise stimulus for the development and use of appropriate renewable technologies and the development of cleaner fossil fuel based technologies in Scotland. A Centre of Scientific Excellence in Energy could be an important means of exploiting Scotland's skills and opportunities. The Scottish Science Advisory Committee is encouraged to produce a strong proposal for it, which the Scottish Executive is encouraged to support.

There is a great deal of waste material that is a potential but unused source of energy. Domestic waste in urban areas, waste from arable stubbles on farms, and waste from restructuring in forests are among the sources. These are best used close to their source as transport costs are high and the energy value per unit volume is relatively low.

The definition of the term 'waste' is crucial in ensuring that all possibilities can be pursued. There appears to be a disagreement between the Scottish Environment Protection Agency (SEPA) and the Forestry Commission Scotland on the definition of 'forest' waste. This is impeding the use of this source of energy.

> **Recommendation 18:** The Scottish Executive should ensure that the definition of 'forest waste' used by SEPA enables state and private forest owners to utilise forestry thinning and other wood materials in energy production.

For transport, there is interest in alternative fuels produced from biomass. The two most common forms of biofuels are bioethanol and biodiesel. Bioethanol is most efficiently produced from material with a high sugar content. Biodiesel can be produced from a wide range of waste sources, tallow from meat rendering and used cooking oil, and from oil crops such as rape seed. In Scotland, the economic conditions are not suitable to support substantial development of biofuels for transport. Biodiesel production from rape, linseed and sunflower crops and waste matter is possible, but the market will not respond until there are sufficient supplies of raw materials and a more competitive position in relation to other end uses to justify the investment in infrastructure.

We welcome the recognition of the potential for biofuels in the 2006 Scottish Executive *'A Forward Strategy for Scottish Agriculture: Next Steps'*, but note that there are no specific actions to stimulate market interest. The market will decide what fuels it can commercially and competitively exploit. This can be influenced by a well defined public policy framework designed to reduce environmentally damaging emissions, provide scientific and commercial opportunities for Scotland, and reduce Scotland's dependence on imported energy sources. We are surprised that the Scottish Executive has not developed fuel substitution targets for the main energy consumption sectors – transport and heating – alongside the target of production of electricity from renewable sources, especially bearing in mind that electricity only accounts for 20% of energy use.

> **Recommendation 19:** The Scottish Executive, as part of the development of its energy strategy, should develop fuel substitution targets for all of the main energy consumption sectors: transport, heating and electricity.

We note that, although the present Renewables Obligation Certificates (ROCs) are available for energy from most renewable sources, decisions taken to date strongly favour market technologies rather than those further from market adoption. 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 targets are not guaranteed beyond 2015, although ROCs are set to continue to 2027. We consider that once a technology has been market proven then it is an unwise policy to continue what amounts to a long-term subsidy. We have profound doubts about the rationale and validity of the ROCs system. It is designed to be technically neutral at the point of energy production by 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. This could be in the form of a levy proportional to the level of carbon emissions. The ROCs as operated perpetuate the use of a given technology, whether it is economic and efficient or not, and do not clearly support Government energy objectives, for example, to reduce carbon emissions and to increase efficiency in energy usage. Introducing specific ROCs, for example for marine power, amounts to 'picking winners'. Alternatively, incentives and disincentives applied at the point of production in the form of a carbon levy, in direct support of policy objectives, will allow the market to decide how best to meet the national requirements. They are truly technology blind and may encourage investment in research to find new and more efficient means of meeting the objectives.

> **Recommendation 20:** We recommend that the UK Government, supported by the Scottish Executive, replace ROCs as soon as possible with a carbon emission reducing measure, such as a carbon levy applied at the point of carbon production. This should build on the existing EU Emissions Trading Scheme. Existing commitments should be honoured.

We regard onshore wind as a mature technology both in Scotland and in other European countries, so we see no justification for the continuation of the ROC's support for this technology, if our proposals for a carbon levy are accepted.

There will always be uncertainty about the future levels of energy use by consumers. Much will depend on consumption drivers, such as the demographic profile, and on economic development, as well as prices of energy. Although technological changes in energy supply will come into operation over the coming decades some, such as nuclear fusion, are many decades from commercial realisation.

We note below our conclusions and recommendations on the use of low carbon sources for the production of hydrogen as a multi-purpose fuel. This represents a capacity to store, in a transportable form, large quantities of energy, but will require financial support for research, development and demonstration. It will be essential that government policy is sufficiently flexible to stimulate new technologies and to provide the policy framework to bring them into operation.

Fuel Substitution for Transport

The transport sector, with its 99% dependency on oil-based fuels, offers considerable opportunities for fuel substitution. Twenty eight percent of energy demand in Scotland is from the transport sector and the majority of this (71%) is from road transport. Any changes in energy use should therefore focus primarily on road vehicles and road users.

We note that the high fuel tax policy of the UK Government and ever more stringent emission controls have guided the market to develop ever more efficient engines. This has included cleaner fuels, lead free and with reduced sulphur content, and the switch from petrol to diesel and to LPG. It has encouraged the development of alternative technologies, such as the hybrid engine and the current interest in hydrogen fuel cells.

We consider that increased incentives should be introduced to further stimulate the move to low carbon fuels. A greater reduction in VAT on hybrid and hydrogen powered vehicles would enhance the attractiveness of these options. Incentives need to be introduced to develop the infrastructure for alternative transport fuel supply.

> **Recommendation 21:** The UK Government should review and improve the incentives to encourage fuel substitution in transport and for the production of biofuels and associated infrastructure.

The transport technologies that are at, or near, market are electricity and hydrogen. For fixed route public transport, the electric option has a long history, and with current concerns about carbon emissions, now is the time to revisit this option. The EU CUTE project is funding trials of hydrogen-powered buses in London, while the EU PURE project in Shetland demonstrates the use of wind power generated hydrogen car fuelling. The uptake of new transport technologies will depend on the availability of fuel, the development of infrastructure for its delivery, and price.

We note that aviation is the second largest user of energy in the transport sector. All of the estimates we have examined predict a continuing increase in air transport in Scotland. We concur with many other commentators that the lack of tax on aviation fuel in relation to its emissions is a major anomaly in the transport sector. We recognise that this is an issue that cannot be resolved in Scotland. We support the proposed inclusion of aviation in the EU Emissions Trading Scheme and hope that the scheme with realistic targets will be introduced in the very near future.

In setting its budgets the Scottish Executive is faced with almost incompatible choices, such as balancing the economic need to invest in roads while simultaneously seeking to mitigate the effects of emissions from transport. We are concerned that due weight to environmental issues, especially in relation to global climatic change, should be reflected in transport policies

> **Recommendation 22:** In the next Spending Review, the Scottish Executive should change the priorities in its transport budget to more adequately reflect its climate change priorities.

We hope that the Scottish Executive will develop energy policy and targets for the railway system, as part of the Scottish Railway Strategy it has to prepare following the transfer of responsibilities from the UK level.

> **Recommendation 23:** The Scottish Executive should develop an energy policy and targets for the railway system as part of the Scottish Railway Strategy.

Fuel Substitution for Heating

We note the rapid development of the use of gas for space heating in recent decades as a result of low price and availability. We also note the benefits this has brought to the domestic consumer. However, we have also expressed our concerns that a second 'dash for gas' may lead to an unhealthy over dependence on this fuel, raising security of supply issues.

We are disappointed that local councils and the building construction industry have not taken the opportunities for the installation of combined heat and power and district heating systems as part of the redevelopment of brownfield sites in many urban areas, and the wider use of heat pumps. As a result, we consider that substantial improvements are needed in the regulation and incentives regimes for the construction sector. We see increased opportunities for fuel substitution for gas, especially from municipal waste, and from biomass. We welcome, therefore, the initiatives proposed in Local Council Waste Plans for the reduction in municipal waste to landfill and the reuse of waste for energy generation over the next decade and a half.

Recommendation 24: Local Councils should undertake the following to improve fuel substitution for heating:

(1) amend Structure Plans and Local Plans to stimulate the development of combined heat and power and district heating schemes in urban areas;

(2) do not approve Planning Permission and Building Warrant to developments on brownfield and greenfield sites without these facilities;

(3) work with the building construction industry to put into effect systems for the delivery of combined heat and power and district heating systems; and

(4) increase the targets for the reuse of municipal waste for energy production coupled with a reduction in material sent to landfill sites in Local Waste Plans.

Recommendation 25: The UK and Scottish Governments should introduce a tax disincentive on waste disposal, especially to landfill, and a greater tax incentive for the reuse of waste for space and water heating as part of District Heating and Combined Heat and Power Schemes. They should also introduce a tax credit system to stimulate the use of biomass and waste for the production of heat for all buildings; and should consider an energy efficient dependent stamp duty and Council Tax as incentives for improvements in building design and construction.

Recommendation 8 is also relevant in this context.

Fuel Substitution for Electricity

The demand for electricity is rising faster than the demand for energy as a whole. Currently Scotland has an installed electricity generating capacity of approximately 11GW against a peak demand of approximately 7GW, leaving a comfortable margin for transmission and distribution losses, industry self use, and export (on average approximately 20% of electricity generated in Scotland is currently sent to England and Northern Ireland). There is a single market for electricity in Great Britain under the British Electricity Trading and Transmission Arrangements (BETTA) system made possible by the national grid system. Great Britain can be regarded as a number of interconnected regions, of which Scotland is one. At present few, if any, regions have an even balance between generation and load. In Scotland's case, there is currently a substantial surplus of generation available for 'export' to the rest of Great Britain through the so-called Scotland/England and Scotland/Northern Ireland interconnectors.

Scotland's electricity is provided by six principal generating stations: 38–40% (in terms of energy output) from the two nuclear stations at Hunterston and Torness, 33–35% from the two coal stations at Cockenzie and Longannet, 16–18% from the Peterhead gas station and 8–10% from distributed hydroelectric stations.

The programme of decommissioning nuclear plant envisages, at this time, the closure of Hunterston in 2011 and Torness in 2023. Proposals to extend the life of these stations will be constrained by the rate of degradation of the graphite cores. It is anticipated that future extensions, in line with current practice, will be for a period of no more than five years.

The EU Large Combustion Plant Directive required energy utilities to sign up to new emission standards by the end of January 2006 or close their plants by 2015. Scottish Power has decided that the Cockenzie plant must close, but that investment in Longannet will allow its continued operation, at slightly reduced capacity, until around 2020.

The closure of the nuclear and coal stations means that Scotland will lose approximately 30% of its large electricity generating plant capacity within ten years, approximately 75% of its capacity within twenty years and the total in twenty five years. Scotland will become heavily dependent on imported electricity, unless new generating capacity is built in Scotland. It should be noted, moreover, that large conventional power stations will also be closing in England in Wales over similar timescales.

There are highly polarised arguments about solutions for meeting future demand for electricity. Some argue that this should be predominantly from renewable energy sources, and others that the supply should be from investment in new civil nuclear generating plants. We consider the confrontational scenario of 'nuclear versus renewables' to be a false debate. Different sources of electricity generation are not interchangeable. The demand for electricity varies throughout the day, the week and the season. Nuclear power does not have the flexibility to follow load demand and is therefore only suitable for base load provision. The inherent intermittency of wind power means that it cannot be relied on to deliver firm output at any given time. However, its input when available has to be accepted into the grid. A diversity of supply is essential to achieve maximum security and flexibility in the supply of electricity.

If informed decisions are to be taken, then there is merit in raising the level of public debate on future options for the supply of electricity. Provision of factual and objective information and stimulation of meaningful consultation that will influence decisions is sorely needed. It is proposed that the Royal Society of Edinburgh through this report and its follow up, and other bodies, stimulate an informed public debate on the electricity supply choices for Scotland within a UK context. It is hoped that this will result in more robust and practical decisions on the diversity of supply sources and the transmission and distribution systems needed.

We have reviewed a wide range of estimates of the cost of different technologies for generating electricity. No entirely comparable figures are available, as some estimates fail to take into account whole life-time costs, some do not take into account intermittency of supply, and others do not estimate the cost of carbon sequestration. We conclude that coal, oil, gas, nuclear, waste and biomass (not fuel crops) co-firing all fall within the same cost envelope of 2–3p/kWh, with onshore wind at 3–4p/kWh, and other options either not yet proven or much more expensive. These costs exclude support through, for example, ROCs. It should be noted that for the fossil fuel fired stations 60% of the cost is in the price of the fuel. In the case of oil and gas, the spot price has more than doubled since the costings were carried out. The sensitivity of nuclear costs to the price of mined uranium is only 4% and to the cost of fabricated fuel 15–20%. The relative costs would change with a carbon emission charge.

We conclude, therefore, that single solutions will hinder Scotland achieving the range of energy policy objectives that we have recommended (Recommendation 4). **We consider that a diversity of supply sources will be essential.**

> **Recommendation 26**: The UK and Scottish Governments should ensure that the framework for energy at both UK and Scottish levels encourages investors to produce electricity from a diversity of supply sources.

We have given more space to electricity because of the degree of contention and our desire to better inform the debate and the decisions ultimately made by government and investors.

Renewables sources for electricity

We favour the continued support of development of renewable energy sources from research through development to near market use. Once marketable, it should be the market that decides what sources to utilise within a policy framework that encourages diversity and seeks to reduce environmental harm. Onshore wind power has now established itself in the market and if our proposed carbon levy is introduced, we consider that it does not need further subsidy.

We note that the Scottish Executive has set a target of 40% of electricity to be produced from renewable resources in Scotland by 2020. We note that it has recently been redefined. However, we have concerns about the validity of this target. There is no explicit rationale for setting an environmental target in these terms, particularly in relation

to carbon emissions. There is also confusion on the definition of the target. We doubt the feasibility of supplying 40% of electricity from renewable sources. We note the conclusions of recent advice to the Scottish Executive that renewables can, in principle, supply on average over a year 40% of the required electricity in Scotland. However, this supply would be intermittent and the level of supply from renewables would be 40% or over for only 40% of the time. As a result, considerable excess capacity from conventional electricity sources would have to be installed to cover for the relatively low load factor from these sources. The target could easily be achieved after the closure and non-replacement of the fossil fuelled and nuclear electricity generating stations in Scotland, but these closures would have profound effects on achieving security of supply.

On the basis of the recently approved Whitelee development in Renfrewshire, we estimate that to achieve a 20% contribution to Scotland's electricity generation would require 1,500 turbines covering a land area of around 600 square kilometres, and a subsidy of about £35m/year.

We consider that the renewables target would have been better defined in terms of the fuel substitution and carbon emissions rather than the generation of electricity.

> **Recommendation 27:** The Scottish Executive should redefine the 2020 target for the proportion of electricity generated from renewable resources in terms of reduction in greenhouse gases to meet the UK's 2050 target on emissions reductions, and set out a detailed and comprehensive strategy for meeting it.

We have grave doubts about the overall economic rationale for large-scale wind turbine installations in locations remote from the consumer. We note from the evidence provided to us that these developments are only commercially viable as a result of the ROCs. Remotely located, large-scale wind turbine installations will require costly new or substantially upgraded grid connections, many of which are highly contentious, resulting in greater transmission loss of electricity from the source to the consumer compared with more centrally located installations. Such investments run the risk of becoming stranded assets if the connection infrastructure is not put in place. We also have concerns about the effects of such developments on landscapes, habitats and wildlife, much of which are of European and International importance. It would make greater economic sense, and is also likely to be more environmentally friendly, if the decision-making system and decision support instruments resulted in the installation of renewables generation close to the main consumption areas and to the grid, and in areas of relatively lower environmental quality. A locational strategy guided by these principles should be drawn up as a matter of extreme urgency by the Scottish Executive.

> **Recommendation 28:** A locational strategy and accompanying planning guidance for onshore wind development should be drawn up immediately by the Scottish Executive to guide Local Councils, investors and third parties, and speed up the process of decision making.

Onshore wind would benefit, both absolutely and relatively, from our earlier proposal for a carbon levy, i.e. it would put all electricity generation alternatives on a level playing field with respect to carbon emissions, so that onshore wind would benefit and fossil fuel plants would be disadvantaged.

Hydroelectricity has long been an important component in Scotland's mix of electricity generation. Large-scale hydroelectric power production requires large volumes of fast flowing water. There is limited scope for new large-scale hydro-electric generation, and we welcome the Glendoe development. There is potential for the development of pumped storage facilities and we consider that these can be a valuable way of storing an energy source from nearby wind turbine installations.

Fossil and other non-renewable fuels for electricity

With the need for large-scale replacement of electricity generating plant within ten years, decisions on the viable options are urgently needed. The choice between the sources therefore has to be on grounds not only of costs but also of public acceptability, of security of supply of the raw fuel, the relative life-time costs and the overall risk of individual technologies to society and to the environment. Within the next ten years, we do not consider that most renewable technologies, including current wind technologies, have the capacity to give the secure and continuous supply of electricity demanded by consumers. Thus the choices are clean coal (including biomass co-firing), gas and nuclear.

There will be plentiful supplies of quality coal from reliable sources, such as Australia, throughout the time frame considered by this Inquiry. Coal has the advantage that it can be safely and economically stockpiled, giving protection against short term interruptions to supply. The variety of sources of supply and the large global reserves mean that the risks to securing the level of coal supply at an affordable price appear to be acceptable. However, until clean coal technology is fully proven, the question of carbon sequestration is not resolved. Investment in a coal plant would have to include retrofitting of clean coal technology as soon as it became available. Collaborative effort will be needed to increase the speed of implementation of new clean coal technology, perhaps with Longannet as the test bed, and the sequestering of carbon in worked-out coal mines. Biomass co-firing only remains an option if there are coal fired power stations.

New gas fired power stations are a more realistic option than coal to meet the range of energy policy objectives. Our support is on the proviso that there is an effective means of dealing with carbon emissions. We support the Peterhead Power Station/Miller Field project which provides the opportunity for CO_2 injection into hydrocarbon reservoirs for tertiary recovery of oil and gas. We note that there are many sources of gas supply, including continuity of supply to Scotland from Norway for the next 25 years and the provision of Liquified Natural Gas (LNG) into the UK market from a variety of sources. As a result, Scotland and the UK do not have to become entirely dependent on the so-called 'end of pipeline supply' from Russia.

A new generation of nuclear power stations should remain an option given their low greenhouse gas emission levels compared with coal or oil-fired stations. We note that the level of radio-active waste which would be produced if new stations replaced the entire current UK nuclear electricity generation capacity would be significantly less over their life times than the accumulation of waste to date.

The UK Committee on Radioactive Waste Management published in late April 2006 its headline recommendation that its preferred option is geological storage. The full Report is due in June 2006. It will then be important to have a wide public debate followed by political decision on how to proceed with the nuclear option. We stress once more that this debate is not a confrontation between competing technologies and to present it in this light is to do a disservice to the public. Realistic decisions will have to take into account public safety, environmental impact, security of supply, full-life costs and the ability to deliver an adequacy of supply. These considerations apply to whatever energy technology is being considered and it is essential that a common method of assessment is developed.

> **Recommendation 29:** Subject to agreement on implementing a satisfactory solution to the very long term treatment of radioactive waste, we encourage both the UK Government and the Scottish Executive to keep open the nuclear electricity generating option in the interests of diversity and security of supply and suppression of greenhouse gas emissions.

The last nuclear station in the UK, built at Sizewell, took over 15 years from planning to operation. It has therefore been claimed that there is no role for nuclear power to deal with the closures of the next ten years. The period to commission a nuclear plant could be shortened by designating existing nuclear sites as already licensed. This has the advantage that the grid connection infrastructure is already in place. There is potentially limited local opposition from communities that have become accustomed to working in and with the nuclear industry and are aware of the health and safety record of British nuclear power stations. The new generation of reactors are half the size and half the cost of the Sizewell reactor. Instead of building plants of a multiplicity of designs, as in the past, the UK should follow the French and USA example of pre-licensing tendered reactor designs. This, coupled to a construction time of five years, might make the nuclear generation option a possible contributor to meeting the "gap" in electricity generation.

It is clear from the above analysis that the long term planning for future energy needs requires a framework allowing confidence in long term investment. If that process is not started now, then there will be a severe crisis when industry plans for the replacement of plant due to close between 2015 and 2025 take effect.

Our overall conclusions on electricity generation are two-fold. A combination of renewable and large generating plant solutions will be needed, so the options for the use of technologies, both existing and new, should be kept open. And improvements in the decision-making systems to provide public engagement and ultimately to provide greater public reassurance on the decisions are needed.

Recommendation 30: Government, industry and political parties should retain options for new build electricity generation from a variety of technologies, specifically renewables, clean coal, gas and nuclear, subject to public engagement to decide whether any technologies should be excluded from consideration.

It is for the private sector to make decisions on the technologies to be used, the preferred location of plants, and the transmission and distribution systems necessary to take the electricity to the market. However, decisions will not be taken unless the UK Government's policy and regulatory framework are unambiguous and long-term and the Scottish Executive's contribution, especially through the planning system and the environmental and other consents needed, is much more integrated than it appears to external observers. Currently, there are too many opportunities to pass responsibilities for decisions to others, resulting in delays. These delays can lead to a limitation on the options available. Decisions will have to take into account public opinions on the choices through careful consultation processes. A joint approach is one way forward.

A critical decision is whether Scotland should have the capacity to meet its peak demand for electricity: this is a matter for the Scottish Executive, the generating companies and the National Grid Company.

Recommendation 31: The Scottish Executive should discuss with the major generating companies and National Grid Company the decisions required by UK and Scottish Governments and also by generators for the replacement of large-scale electricity generating stations in Scotland. They should take into account the public engagement in Recommendation 30.

Electricity markets and the operation of the national grid

There is a single market for electricity throughout Great Britain and hence no imperative to build new generating capacity in Scotland. Ofgem, the industry regulator, has approved a grid connection charging policy by the National Grid Company to recoup the costs of delivery of power to bulk supply points.

Since privatisation, the margin in installed capacity relative to peak demand has reduced from around 30% to around 20%. Clearly significant new generating capacity must be built throughout Britain so that the plant margin does not fall to dangerously low levels.

The charging policy means that additional generating capacity installed in Scotland faces higher connection costs than the equivalent capacity installed in the south of England. Existing plant already pays the connection charge, thus replacement plant of the same capacity, installed on an existing generating site should not incur additional costs. Such replacements in Scotland would continue to attract higher charges than those for an equivalent replacement in England.

If replacement capacity is not built in Scotland and the utilities build new generating capacity in the south of England, the grid will require to be modified to carry substantial quantities of power from south to north. This will require not only upgrading of the Scotland/England interconnector, but also adjustments to the grid in the north of England to facilitate the flow. The National Grid Company will only change the level of connection charge when the cost of grid development exceeds the cost incentive to build plant in Scotland. The danger of this market-driven approach is that the timescale on which replacement decisions have to be made may limit the options for the choice of generating technology. We are concerned that limits on the Scotland/England interconnector threaten security of supply in Scotland if no replacement generating capacity is located in Scotland.

In order to reduce the connection costs to the grid of new generating stations, we recommend that replacement generating capacity is built on the sites of decommissioned power stations where the infrastructure connections already exist and for which additional charges should not apply, if the installed capacity remains the same.

Recommendation 32: Government authorities with approval powers, and generating companies should favour the construction of new large-scale electricity generating plant adjacent to existing plant, with easy access to the grid.

The existence of a source of energy does not guarantee that it can be delivered economically to the market. The continuation of a programme of encouraging the development of renewable sources must include an assessment of the infrastructure implications, especially the extension or upgrading of the electricity infrastructure.

Recommendation 33: The Scottish Executive should carry out a review of the electricity infrastructure implications of its renewables policy, especially in light of the National Grid Company's grid connection charging policy.

Distributed energy systems

Our Inquiry has found that there are many opportunities for more distributed energy generation in urban areas, in locations adjacent to existing generating stations, in the remoter areas of the mainland, and on the islands. Already there are small-scale schemes operating, for example hydrogen generation on Unst, tidal power generation on Islay, and district heating schemes in Lerwick and in Wick. There are a number of other opportunities that should be developed for local energy consumption. Points of high natural energy, such as wind, tide and wave power, small-scale hydro and waste heat from industrial plants, for example distilleries, should be developed for local benefit, provided that they do not cause environmental damage.

These developments would provide innovation, especially in the remoter parts of the country, and provide partial self-sufficiency in energy. Local power schemes under community control have the potential to contribute to what are often marginal economies. There are many examples of innovative schemes and these are described in the main report. We see the need for knowledge of these approaches being made more widely available. The following Recommendations should be facilitated by the proposed Energy Agency for Scotland.

Recommendation 34: The various energy use advisory bodies should compile examples of distributed systems and ensure their wide dissemination.

Recommendation 35: Joint initiatives by local enterprise companies, applied research and development groups, private enterprise, and especially local community groups, should exploit locally available energy resources for local use.

Research, development and demonstration opportunities for Scotland

Scotland has an enviable track record in energy related research and development, and currently a number of technologies are being successfully brought into operation in Scotland and elsewhere. Encouragement is needed in various ways dependent on the state of technological development and its nearness to commercial operation. We identify three *domains:*

For the *mature technology domain*, we consider that this is a matter for private investment, with government ensuring that the appropriate instruments and policies are in place. For example, Scotland has experience in mature oil and gas field recovery, where North Sea production continues to be extended and a substantial export potential has already been demonstrated. We expect these developments to be led by the oil industry.

For the *near market domain*, we consider that there is a need for joint public and private investment to build up the skills base on all fronts to improve the chances of technologies successfully reaching the market place.

For the *upstream domain*, we recommend that ITI Energy maintains a watching brief and provides the necessary guidance and support, with the help of other bodies, to bring developments to commercial realisation.

We consider that there are excellent opportunities for Scotland in four broad areas of energy research, development and demonstration:

(1) 'Clean coal' technology and carbon sequestration

Scotland is well placed to play a leading role in developing and implementing clean coal technology and carbon sequestration, and applying its skills to developments elsewhere. All the essential requirements are in place to permit major development of this potential: the infrastructure of the North Sea oil industry, and the engineering, geo-engineering and geological skills, backed by powerful relevant research capacities in the Scottish Universities and the British Geological Survey in Edinburgh.

An important priority is to strengthen an already powerful research effort in Scotland, to ensure that it plays a pivotal role in developing concepts and technologies and is able to capture a major share of national and EU research funding in the field.

(2) Electricity distribution networks

A "smart" network able to accept distributed generation and with the flexibility to incorporate new technologies over the next 50 years is likely to be a priority both in Britain and elsewhere. Scotland's geography and population distribution, the need to supply a small number of major conurbations and a very large number of remote locations, and the potential for major renewable generation far from major population centres, make it an ideal laboratory that could attract power companies to undertake meaningful scale demonstration projects. This opportunity is complemented by the strength of Scottish research capacity in networks and power electronics.

(3) Low carbon generation of hydrogen

ITI Energy are involved in a project investigating the production of a low-cost, solid nano-material with the potential to store and release hydrogen at room temperature and low pressure. The resulting material could have a range of important energy applications, such as fuel cell and battery systems. Successful development of this material would enable Scotland to establish its position in an important area of clean energy technology, hydrogen storage and a range of industrial processes involving hydrogen. The R&D project and the associated commercial development is based in Scotland. In addition, the Forum for Renewable Energy Development in Scotland (FREDS) has established a hydrogen and fuel-cell energy group that is still to report.

There has been development and deployment of fledgling hydrogen technologies from renewables in Scotland. Although this has been on a small scale, such developments could be highly significant for rural communities. An example of such a development is that on the island of Unst. Although such work is necessarily limited in scale and global impact, it has the potential to create additional diversity of supply that could be of great value in outlying communities. It is to be hoped that Scottish groups will be at the forefront in exploiting opportunities under the UK government's initiative, which could be facilitated by a strategic perspective for hydrogen developments in Scotland.

There are many small-scale projects, such as the Unst scheme and the Lothian hydrogen powered office, and other larger schemes such as the Peterhead Power Station/Miller Field, as well as opportunities in other parts of Scotland to link research with practical application.

> **Recommendation 36:** The Scottish Executive should carry out a detailed appraisal of the potential for hydrogen to contribute to Scotland's energy mix.

(4) Offshore wind, wave and tidal technologies

There is a long-standing academic and industrial research interest in marine wave and tidal power in Scotland. The establishment of the European Marine Energy Centre in Orkney has led to the design and construction of the World's first large-scale wave generator – Pelamis – in Scotland for installation in Portugal. This area of activity has great potential.

Development of offshore wind generation in the UK is proving excessively slow, such that the enormous potential of the Scottish west coast in particular, and the potential for associated commercial exploitation, risk not being realised. The gap between capital costs, expected operational costs and revenue for most projects remains too large for substantial industry commitment. The uncertainty about real future costs is a major problem. Turbine prices are increasing as global demand expands, reliability is uncertain, raw material prices are high and grid connections are uncertain. It is important that discussions take place to establish whether some of the above risks can be mitigated, by a regime of capital grants and adjustments to economic instruments.

Timescales for decisions

A number of key decisions need to be made in the near future if replacement plants and other infrastructure is to be available and the requisite strategies and policies are in place. These are summarised in the table below:

Decision	When	By whom
UK Energy strategy	Mid 2007	UK Government
UK energy targets	End 2006	UK Government
Scottish Energy strategy	End 2007	Scottish Executive
Emissions targets for Scotland	End 2007	Scottish Executive
New electricity generating plant	Mid 2007	Scottish Executive/generators/ National Grid Company
National Grid upgrade in Scotland	Mid 2007	National Grid Company/Ofgem
National Grid upgrade Scotland/England	Mid 2007	National Grid Company/Ofgem

Engaging the public

With an issue as complex and broad ranging as Scotland's energy policy, it will be important to encourage reasonable expectations of what can be achieved by public engagement. The purpose of dialogue is not to determine, but to inform, policy making and decisions. It does this by challenging the thinking of policymakers and technical experts who contribute to decision making. Government must retain the responsibility for making the decisions.

In the case of energy, we have pointed out the need for a Scottish strategy to be formulated by the end of 2007, and we have recommended that decisions on new electricity generating capacity are made in the same timeframe. We recommend that a process of public engagement begins in the next few months with outcomes reported on these aspects to government by the summer of next year. It is preferable that this is undertaken independently of the Scottish Executive. We consider that existing independent bodies, such as the Royal Society of Edinburgh, and others of the same type, should jointly undertake this exercise on behalf of the Scottish Executive.

> **Recommendation 37:** The Scottish Executive should invite independent bodies, such as the Royal Society of Edinburgh, jointly to design and conduct a process of public dialogue and deliberation. Based on the outcomes of this process, they should make recommendations to the Scottish Executive about the range of technologies that should be acceptable as part of an energy mix in Scotland to ensure security of supply and economic competitiveness and to support the transition to a low-carbon economy. The process should be launched as soon as possible after publication of the UK Government energy review, and completed in the summer of 2007 at the latest.

Envoi

The World is facing an enormous challenge to meet the legitimate aspirations of the developing world, with the consequent growth in energy demand, while at the same time trying to mitigate the potentially catastrophic impact of global climate change. Against this background the EU, especially the UK and thus also Scotland, are seeing the need to rely more and more on imported energy at a time when the international market in energy grows more competitive. The developed World, including the UK, has a special responsibility, (as signalled in Kyoto Protocol) to carry the burden of an early reduction in greenhouse gas emissions.

Scotland has a long history of innovation. There is considerable relevant research expertise in its strong academic community and, although considerably diminished, experience and skills in our industrial sector. In addition, Scotland is rich in new alternative forms of energy with a potential for exploitation and the capacity to improve technologies for existing energy sources. The UK Government must be convinced of the need to exploit these resources, not only for our own good, but as part of our contribution to the global challenge. This will require a policy framework that will not inhibit the exploitation of our natural resources and allow us to continue to contribute to the UK, and indeed Europe's power requirements.

For success, it will be necessary to use technologies in a timely fashion as they become marketable. The policy framework must strongly shape the market to national objectives without trying to dictate how these are to be met, i.e. no trying to pick winners. It is crucial that there is no confrontation between competing technologies and maintaining diversity of supply.

In searching for the way forward, we should always be prepared to learn from others, but never be prepared to implement anything less than best practice. Our Scandinavian neighbours can teach us much about energy efficiency, but we do not always have to look abroad for guidance. There are many examples of good practice here at home and we should strive to promote these so that they become common practice.

The challenge is great and Scotland has an opportunity to meet it, not only for its own needs, but as a partner in the UK. With the development of the right technologies and skills we have the potential to export these and contribute to the global challenge.

Professor Maxwell Irvine (Chairman)

Professor Geoffrey Boulton

Professor Roger Crofts (Secretary)

Dr Robert Hawley

Dr Malcolm Kennedy

Professor Andrew Miller (Vice-Chairman)

Professor Janet Sprent

Professor Joyce Tait

Dr George Watkins

June 2006

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