SCOTTISH ENERGY 2020?

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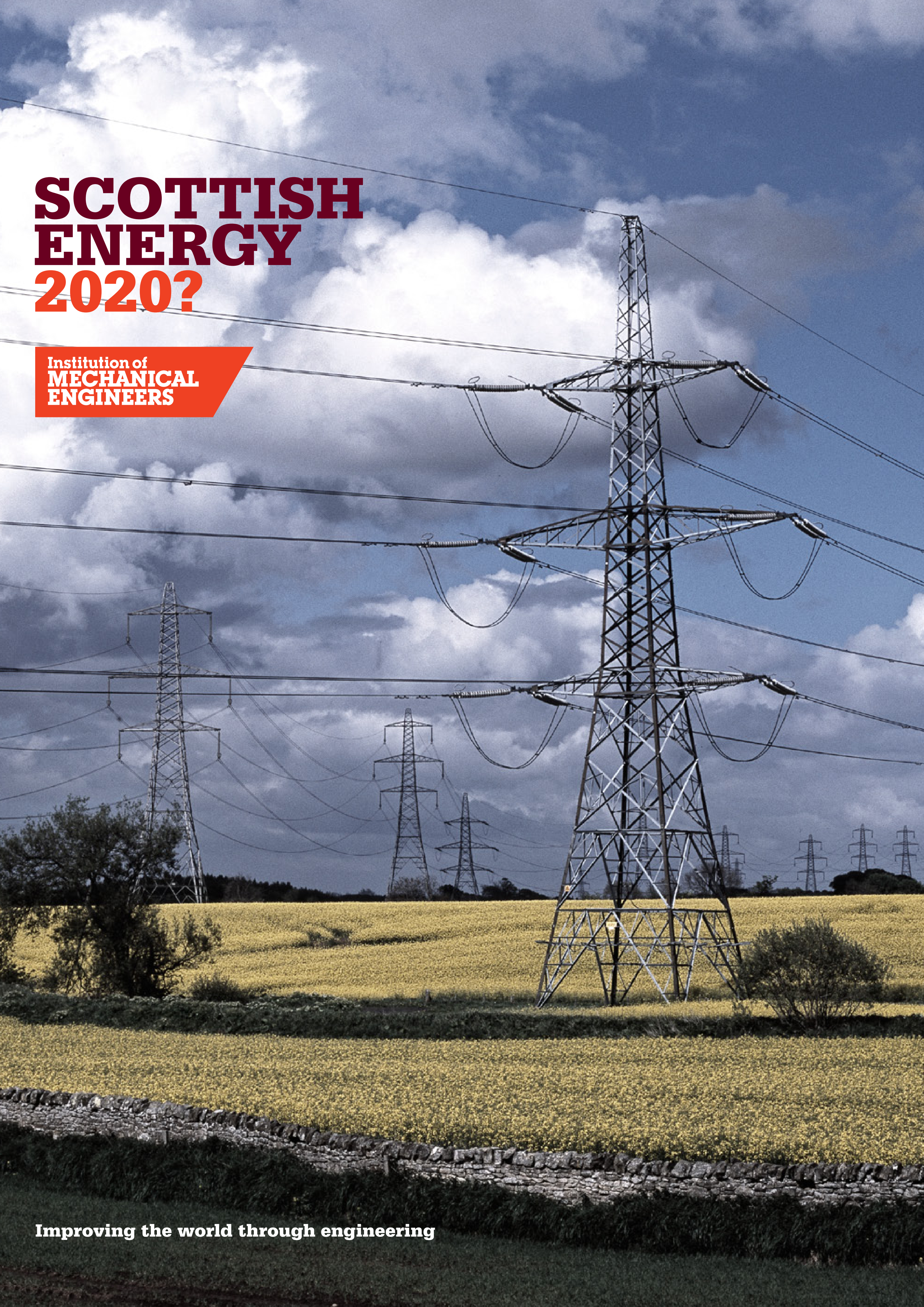

Improving the world through engineering

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IMECHE SUPPORTS THE ASPIRATION OF THE SCOTTISH GOVERNMENT TO FULLY EXPLOIT THE POTENTIAL FOR RENEWABLE ENERGY THAT EXISTS IN SCOTLAND.

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This report examines the engineering viability of the Scottish Government's commitment to generate 30% of energy from renewable sources by 2020, the issues of intermittency and fuel poverty.

This report has been produced in the context of the Institution's strategic themes of Energy, Environment, Education and Transport and its vision of 'Improving the world through engineering'.

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EXECUTIVE SUMMARY

INTRODUCTION

The analysis presented in this report was undertaken by the Institution of Mechanical Engineers in response to the Scottish Government's declaration that by 2020, 20% of the total energy demand in Scotland would be met from renewable resources. This exceeds the 15% target that the EU Renewable Energy Directive (2009) requires the UK to meet as a whole. More recently the Government also announced that 100% of electricity generation will come from renewables by the same date. The Institution's findings suggest that the original renewable energy target split for Scotland of 50% electricity, 11% heat and 11% energy for transport, making the overall 20%, and subsequent revision of the electricity generation target to 100%, did not appear to be supported by a rigorous engineering analysis of what is physically required to achieve a successful outcome in the timescale available.

During the research for this report, First Minister Alex Salmond announced that the Scottish Government had increased the overall percentage target for energy from renewable sources to 30% by 2020. In light of this report's analysis, this aspirational target appears to represent an ambition that cannot be justified from an engineering perspective. In the absence of a credible publicly presented plan to deliver Scotland's renewable energy at the scale required, the Institution of Mechanical Engineers considers here what these targets mean from an engineering viewpoint.

SCOTLAND'S CURRENT 'ENERGY BALANCE'

In 2008, the UK's total energy consumption was 1695 TWh/y, split: Heat Energy, 710 TWh/y (41.9%); Energy for Transport, 598 TWh/y (35.3%); Electricity, 387 TWh/y (22.8%). For Scotland, agreement does not exist on a set of figures for such a split, which in itself means that data for Scotland's point of departure, against which the outcomes from its energy policy can be measured, is not defined. However, from data reviewed by the Institution, the projected set of figures published in the Scottish Renewable Forum's 2006 'Routemap' were considered the most reliable, and these are used as the basis of this report. On a similar basis, the projections for 2020 were: Total energy 183.1 TWh/y, split: Heat, 89.7 TWh/y (49%); Transport 55.0 TWh/y (30%); Electricity 38.4 TWh/y (21%).

What these findings illustrate is that the term 'Energy' is often confused with 'Electricity', a mistake often made in the media and in Government communications. Electricity is actually projected to be the smallest component of Scotland's energy demand (heat and transport energy being greater). This leads firstly to the conclusion that the focus of the nation's energy policy on electricity is misplaced. Secondly, that even if Scotland's electricity supply could be developed to source totally from renewables in a robust, secure and reliable manner, this would barely achieve the overall 2020 20% target.

Most of the recent renewable energy installations deployed in Scotland in the electricity sector have been based on intermittent, unpredictable resources like wind and solar. However, it is important to recognise that if a larger contribution is to be achieved through renewables, there must be a readjustment to provide more of the proportion from on-demand, predictable resources like biomass and energy-from-waste. In this regard it is vital that the differences between 'installed generation capacity', measured in MW or GW, and the **actual** amount of electricity supplied from the installations in MWh or GWh is clearly understood.

CURRENT POLICY THINKING – SCOTLAND'S 2020 COMMITMENTS FOR ENERGY AND EMISSIONS

Scotland has substantial potential resources for renewable energy and, partly in recognition of this, the Government has committed itself to exceeding the UK's 2020 commitment, primarily through the use of electricity. In July 2009, a grouping of NGOs produced "The Power of Scotland – Renewed" report which attempted to demonstrate that renewable resources could meet between 60% and 143% of Scotland's projected annual electricity demand by 2030.

Subsequent policy thinking on energy appears to have been strongly influenced by this argument and the level of debate in the public domain has been somewhat limited. However, the report was based on idealistic solutions and not backed up by a detailed engineering analysis of how these targets could be practically achieved through a workable approach to delivery. In particular, consideration was not given to the need to provide large amounts of back-up generation technologies that can deliver electricity on demand, most likely from fossil fuels, to support the deployment of intermittent renewables on the scale proposed.

The greenhouse gas (GHG) emissions target that Scotland has adopted for itself is a 42% reduction below 1990 levels by 2020, with an 80% reduction by 2050 (the equivalent numbers for the UK as a whole are 34% and 80% respectively). Scottish policy thinking in this area appears to be largely based on a belief that GHG emissions will automatically be reduced if sufficient renewable energy technologies are deployed, particularly for electricity generation. However, the provision of 'on-demand' energy conversion technologies needed, very likely fossil-fuelled, to back-up the intermittency inherent in deploying large amounts of wind, solar and wave technology will have an impact on net emissions saving that does not at this stage appear to have been recognised.

FUTURE THINKING – 'ENERGY HIERARCHY' AND SUSTAINABLE ENERGY POLICY

Any 21st century energy policy must be sustainable. To guide the development of sustainable energy policy, the Institution created the 'Energy Hierarchy', a simple tool stating that energy policy must start with energy demand reduction, and then proceed with improving energy efficiency **before** considering different types of energy supply.

The concept of energy **conservation** is simply about eliminating the need for energy in the first place and subscribes to the notion that a kilowatt saved (not used) is more valuable than a kilowatt supplied, whatever the source. Energy **efficiency**, however, is about improving the energy efficiency of both the demand-side and the supply-side.

Only when the first two tiers of the Hierarchy have been fulfilled, should more effective ways of supplying energy be considered. Current Scottish energy policy fails in this regard by promoting supply-side technologies before first dealing with demand-side issues.

REVIEW OF THE BARRIERS TO SCOTLAND ACHIEVING ITS 2020 TARGETS

Many of the Institution's members work in the energy sector and are critically involved in delivering the machines, equipment and devices which are necessary to meet the 2020 targets. In reviewing the practical issues related to achieving a successful energy outcome for Scotland, the following points were identified.

Technology

A number of technologies used in renewable energy systems have been available for decades, but significant development work is still required to improve the efficiency of their performance and reduce the cost of maintenance, as well as simplify manufacture and reduce equipment and deployment costs. This is particularly the case for electricity generation from offshore wind, upon which much of Scotland's energy policy is focused.

Many believe that the future of renewable energy in Scotland lies with a wide range of marine devices. Yet the fact remains that there is a great deal of expensive and time-consuming research, development, deployment and decommissioning (RDD&D) work ahead before these technologies are available for deployment in large quantities at a meaningful scale. Further, to support increased use of intermittent renewable sources, technology needs to be developed in the areas of smart metering and smart grids, and even more crucially in energy storage if large amounts of back-up on demand generation are to be avoided.

Infrastructure

The UK National Grid was built to connect large centralised electricity generating plant to industrial and domestic customers. However the situation has now changed significantly and the grid is increasingly required to integrate remote power generators using local renewable sources. Furthermore, much of the Grid asset is reaching the end of its design life and requires updating. A multi-billion pound investment is needed in order to tackle both of these issues and make this infrastructure fit for purpose in the new energy regime. Further, in the case of heat energy, there is no significant, available delivery network in Scotland and little thought appears, as yet, to have been given to this issue.

Skills

Even if it were possible to resolve the technology and infrastructure issues in the short timeframe available to 2020, there are still major concerns in the engineering community regarding Scotland's ability to provide the human resources needed to design, project-manage, install and commission the volume of equipment that will be required to meet such ambitious targets. One strategic approach to this challenge might be to assume that appropriately-trained people from overseas will be able and willing to work in the renewable energy sector in Scotland. However, many countries across the globe are also aiming to meet challenging renewable energy targets over the next few years and it is not necessarily certain that such people could be attracted to work in the sector in Scotland rather than elsewhere.

Manufacturing capability

Although Scotland is by no means devoid of manufacturing industries, the country does not have a sufficient manufacturing base for the large volume of equipment which will be required to meet the 2020 targets. A successful manufacturing base would be provided by a combination of large corporations and SMEs. Large corporations will only invest in new manufacturing capacity in Scotland if the market conditions are right; this is particularly true of overseas companies without current facilities in the country. SMEs, on the other hand, particularly those making specialist components as part of a supply chain, are much more likely to want to set up manufacturing facilities in the country, but in many cases find the levels of red tape they have to cope with too daunting.

Funding

In the current economic climate, SMEs are finding it particularly difficult to access the finances necessary to build their businesses to be able to provide the goods and services required to meet the 2020 targets. Large renewable energy projects, in particular offshore wind, can be funded by multi-national corporations (MNCs) from their own balance sheets, and there is often no need for them to seek external funding. Whereas SMEs, along with local communities, do not have an equivalent finance base and must obtain funding from external sources for smaller-scale projects and/or manufacturing equipment. These issues make business opportunities unattractive and therefore stifle the expansion of the renewable energy equipment manufacturing base in Scotland.

FUEL POVERTY IN SCOTLAND

The 2003 UK Energy White Paper made 'fuel poverty' one of its four main policy objectives. However, rather than improving the situation, fuel poverty has actually worsened since 2003. The Scottish Government has pledged to ensure that by November 2016, so far as is reasonably practicable, people are not living in fuel poverty in Scotland. The reality is that the fuel poverty rate in Scotland fell from 35.6% in 1996 to 13.4% in 2002. However from that point onwards, the rate has been steadily rising year-on-year to 32.7% of households in 2009 – almost back to the 1996 levels.

Although in recent years this may be a result of increased fuel prices being only partially offset by rising incomes and energy efficiency increases, the figures reveal that fuel poverty was rising sharply well before the current economic downturn began in the UK. Scotland clearly has a particular problem in this area which is not being adequately addressed. To achieve a zero fuel poverty target by 2016 with fuel poverty forecast to continue to rise over the next few years will be a very major challenge, especially with the various market incentives for renewable energy inevitably contributing to generally higher energy costs.

RECOMMENDATIONS FOR A SUSTAINABLE SCOTTISH ENERGY POLICY

The Institution of Mechanical Engineers supports the aspiration of the Scottish Government to fully exploit the significant potential for renewable energy that exists in Scotland. This must however be founded on a pragmatic engineering approach to what can actually be achieved and on what timescales. Even within the power generation sector, a relatively straightforward area compared with heat and transport energy, the ability to achieve large percentages of electricity supply from 'intermittent' renewable energy resources is technically challenging both in engineering and policy terms. As a first step towards creating a successful policy for Scotland's renewable energy exploitation project, the Institution makes the following recommendations.

a **Understand and agree the starting point**. The Scottish Government should, as a matter of absolute priority, establish, agree and publish the current position in TWh/y of the gross energy consumption in Scotland in the three component fields of Heat, Transport and Electricity. It should then determine its targets for 2020 (using SMART principles) in the same three fields. The inter-relationship between these three fields must be clearly understood and their relative positions in the 'energy mix' defined and made publicly available. Only clearly-defined measurable targets can be intentionally achieved.

b **Lay out an engineering based plan to achieve the targets**. If the present target of 100% electricity from renewable energy sources by 2020 is to be maintained, then the Scottish Government should clearly state its engineering-based methodology for achieving this ambitious target. In this regard Government should consult with competent and independent engineering professionals who have knowledge and experience in the actual delivery of major power projects. This will establish what level of electricity generation from renewable energy sources can realistically be built in Scotland and in what time period. This will also involve determining the skill levels, manufacturing capability and funding obstacles as well as the numerous outstanding technology and infrastructure issues that still need to be resolved.

c **Create policies that effectively tackle fuel poverty in Scotland**. The Scottish government must prioritise the sourcing of secure, reliable energy supplies for the nation's electricity, heat and transport requirements, while effectively tackling the growing issue of fuel poverty. The latter must be addressed within Scottish energy policy to ensure that an increasing number of people are not tipped into fuel poverty simply because of the increased cost of providing renewable based energy. Such an outcome would create an unsustainable position for the Scottish people.

INTRODUCTION

The announcement in April 2011 by First Minister Alex Salmond, that the Scottish Government had increased its target for the generation of electricity from renewable energy sources to 100% (from the 80% announced in September 2010 and 50% previously) generated considerable interest in the UK press and broadcast media.[1,2] Prior to this, Scotland had already unilaterally declared that the overall provision of energy from renewables as a proportion of the country's total energy demand should be 20%, which in itself exceeds the figure that the EU Renewable Energy Directive[3] requires the UK as a whole to meet (15%). Similarly the 2020 target for the reduction in greenhouse gas (GHG) emissions relative to 1990 levels is greater in Scotland (42%) than is the case for the entire UK (34%).[4] However, despite setting these challenging targets and adopting the ambitious aspirations they represent, the Government does not appear at this time to have a coherent plan to support delivery of this large-scale engineering task over the next nine years. Indeed, there are currently no credible strategies, from a technical point of view, published by Government and available in the public domain.

In July 2009, a collaborative group of NGOs published an influential report[5] which attempted to demonstrate that renewable energy could meet between 60% and 143% of Scotland's projected annual electricity demand by 2030. More recently in the autumn of 2010, the Scottish Renewable Forum (SRF) published[6] various scenarios of higher and lower proportions of renewable electricity, as well as higher and lower levels of electricity demand, but did not propose a practical strategy for achieving the then 80% renewable electricity target. Furthermore, the recently-published Compendium[7] of Scottish Energy Statistics & Information claims to demonstrate how a target of 80% renewable electricity by 2020 can be achieved (though it actually shows only about 75%). However, it should be noted that in this document the 20.5GW of power identified to come from 'renewables' is a figure for 'installed capacity' and does not therefore take account of the intermittent character of some of these energy sources. For example, in the Compendium scenario, onshore and offshore wind account for 86% of the renewable electricity generated, with no allowance having been made for the requirement of other (non-renewable) power plant to back up this intermittent form of generation.

There are clearly energy security issues arising from this approach. From an engineering perspective, none of these reports present energy plans or policy recommendations which would actually deliver the desired outcomes.

The Renewable Heat Action Plan for Scotland[8] expands on the statement in the Compendium that: *"As heat accounts for around half of Scotland's total energy use… The Renewable Heat Action Plan for Scotland (2009) set a target of 11% of the heat consumed in 2020 to come from renewable sources, this target is equal to an estimated 6,420 GWh of heat energy from renewable sources by 2020. Scotland is currently (2009) producing some 1.4% (845 GWh) of total heat use from renewable sources…".* If 11% is represented by 6,420 GWh/y, then the total heat demand is about 58 TWh/y, which appears low compared to other statistics.

In December 2010, the UK Department for Energy & Climate Change (DECC) published its annual Energy Trends document,[9] which reported the proportion of renewable electricity generated in Scotland to be 20.9% in 2009 (but the actual makeup of this number in types of renewables is not specified). Although this overall figure is encouraging (despite a dip in output in 2010[10] due to low wind speeds and rainfall), it is important to note that in Scotland the renewables target (100% of electricity by 2020) is expressed in Energy Trends as "generation by proportion of gross electricity consumption". The latter is defined as "generation plus transfers into Scotland less transfers out of Scotland". In 2006 this percentage was 16.9%, rising to 20.2% in 2007, 22% in 2008 and 27.4% in 2009. However, this could be misleading, as it appears to be a statistical calculation which is not practically measurable. Currently, whether these imports and exports of electricity were generated from renewable resources cannot be known.

In the absence of a credible publicly presented plan to deliver Scotland's renewable energy targets, this report by the Institution of Mechanical Engineers considers from an engineering perspective, what will be necessary to meet the declared aspirations and within what time-frame. The analysis work was undertaken within the context of the generally-accepted SMART principles for project delivery, i.e. the targets must be: **Specific, Measurable, Achievable, Realistic and Time-based.** Engineering experience has shown that project targets which are not bound by these constraints are rarely reached.

THE 'ENERGY HIERARCHY' AND SUSTAINABLE ENERGY POLICY

To guide the development of sustainable energy policy, the Institution created the Energy Hierarchy,[11] a concept which has been adopted by many organisations in the UK, as well as by engineering institutions around the world.

The concept is a simple one, although it has profound implications for energy strategy and policy. The 'Energy Hierarchy' states that a competent energy policy must start with energy demand reduction and then with improving energy efficiency **before** different types of energy supply are considered. The Energy Hierarchy is summarised as follows:

MOST SUSTAINABLE

Priority 1: Energy Conservation.

Priority 2: Energy Efficiency.

Priority 3: Utilisation of Renewable, Sustainable Resources.

Priority 4: Utilisation of other Low-GHG-Emitting Resources.

Priority 5: Utilisation of Conventional Resources as we do now.

LEAST SUSTAINABLE

Energy conservation is about eliminating the need for the energy demand in the first place. The concept is simply that a kilowatt saved (or not used) is much more valuable than a kilowatt supplied, no matter what the source. Energy conservation can often be achieved through behavioural changes; for example, not making a journey and conducting a meeting by teleconference instead. Nevertheless, engineering solutions such as smart meters and real-time displays also have an important role to play in energy conservation, though how much they will actually influence behaviour change remains to be seen.

The second tier of the Hierarchy, energy efficiency, affects both energy demand and energy supply. On the demand side, enormous savings can be made by the use of more-efficient domestic appliances, more efficient vehicles, more-efficient heat delivery systems, and so on. However, it is on the supply side that energy efficiency can significantly affect Scotland's future choices.

In a modern fossil-fuelled power station for example, the steam turbine generator system can have its efficiency significantly increased by the use of supercritical or ultra-supercritical steam, which gives a much larger power output from the same quantity of fuel. Furthermore, if the waste heat energy produced by the plant is harnessed and utilised, as is commonplace in most other European countries, the overall efficiency of the power plant is greatly increased; the heat energy is provided from the same amount of fuel that would have been used to generate the electricity in the first place, thereby leading to an efficiency gain.

The other three tiers of the Hierarchy are concerned with the supply-side for energy, and assume that demand reduction and efficiency have already been considered and implemented. The third tier is about the utilisation of renewable, sustainable resources to supply energy in many forms, not solely electricity. The latter is the Scottish Government's focus on energy provision and clearly this misses the contribution to be made by delivery of renewable energy in other forms, such as heat, and from other tiers in the Hierarchy.

The fourth tier concerns the utilisation of low-GHG-emitting resources; a good example of this is the use of nuclear generation for base-load electricity, as is currently the case in Scotland. Although nuclear power is not accepted by some as a sustainable technology, if an important objective of an energy strategy is to support a reduction in GHG emissions from electricity generating plant, this is a much more sustainable option to include than some other conventional methods. Another example of a tier four approach is utilisation of a carbon capture and storage (CCS) system to reduce CO_2 emissions from conventional fossil-fuel plant, though it should be noted that the application of this method will reduce the plant's energy efficiency.

The fifth tier of the Hierarchy, namely the utilisation of conventional resources, is clearly the least sustainable option and is unlikely to form any part of a future sustainable energy strategy.

The main purpose of the Energy Hierarchy is as a tool that can guide policy makers towards the most sustainable solutions for future energy needs. Each policy development must however be considered on its own merits. For example, a policy that is based on using only one type of intermittent resource, no matter how renewable, to provide all its energy, or even electricity, needs is extremely unlikely to be sustainable in overall terms.

Tension between energy and emissions policies

In formulating policy recommendations, the Institution has recognised for a number of years that there is often significant tension between a viable energy policy and a viable greenhouse gas emissions policy. For example, deploying a large percentage of intermittent 'renewable' energy sources in a system for electricity generation might require the provision of back-up capacity in the form of fossil-fuel-fired plant. This does not necessarily reduce overall emissions substantially enough, or improve security of energy supply. There are often unwarranted assumptions made that renewable energy will automatically have the desired climate change mitigation effect or enhance energy security, and care must therefore be taken in this regard when developing plans to deliver GHG-reduction targets.

The March 2011 edition[12] of DECC's UK Energy Trends provides an illustration of the potential outcome of these tensions. In this regard the data presented showed that the penetration of renewables in UK electricity generation actually fell slightly from 7% in 2009 to 6.9% in 2010.

However leaving aside the fact that 6.9% is somewhat short of the 10% target for 2010, it must be noted that electricity generation from nuclear reduced from 17.6% to 15.6% and coal-fired power generation increased from 27.8% to 28.4%. This means that, as well as the below-target trends in the proportion of renewable electricity, the decrease in the type of power generation from the lowest GHG-emitting generator and the increase in the highest GHG-emitting generator, inevitably mean that there will have been a large increase in GHG emissions over the year in question.

Energy is not electricity alone

The term energy does not mean electricity alone. This confusion appears very frequently in the media, as well as Government communications. A recent example was the announcement by the Scottish Government in September 2010 of the previous 80% target for renewable electricity: "Target for renewable energy now 80 per cent";[13] in fact, the renewable energy target remained at 20%.

Technically, 'energy' is regarded as the actual amount of energy supplied (or consumed) and is typically expressed in *joule* (J), whereas 'electricity' is generally considered in terms of 'power' which is measured in *watt* (W); there is a time relationship between the two in that power is a measure of energy supplied/consumed per unit time (1W = 1J/s). In the energy industry, it has (unfortunately) become customary for the term 'power' to be used to mean 'electricity' while 'energy' is generally used to refer to the non-electrical sector, e.g. 'heat energy'.

INSTALLED CAPACITY AND INTERMITTENCY

When statements are made concerning 'power' or 'energy', it is of crucial importance that the differences between 'installed capacity', usually measured in 'megawatt' (Million Watts – MW), 'gigawatt' (Billion Watts – GW), or 'terawatt' (Trillion Watts – TW), and the **actual** amount of energy supplied or consumed over time (in GWh, gigawatthour, or TWh, terawatthour) is clearly understood.

For example, the 'installed capacity' of an electricity generating plant is generally the maximum output that the plant can produce. The power it **actually** produces at a given time depends on the circumstances. For conventional generating plant (e.g. coal or gas fired plant), power can be supplied on demand. The actual output will be determined by customer demand at any given time. For intermittent generating plant, such as wind, the actual power output at a given time is dependent on the availability of the wind and not on customer demand.

A conventional generating plant is typically available for operation for more than 90% of the time (10% being required for maintenance) and capable of generating at its full capacity for that time. A wind power plant, on the other hand, can generate electricity only when the wind is blowing at a speed within a suitable range. The amount of power it will actually produce is entirely dependent on that wind's velocity. At its minimum wind speed, the plant will generate virtually nothing. It will reach its full power output only at considerably higher wind speeds, typically a velocity of 12–15 m/s. If the wind speed increases further to exceed a critical maximum, the turbine will need to be shut down.

This in turn means that the output from any given wind farm (say, for argument's sake, with an installed capacity of 100 MW) will vary substantially in accordance with the wind speed and not customer demand. Thus, at any given time, the output of a wind farm will be between 0MW and 100 MW (for the example given) and it is not possible to forecast the actual output far in advance for a given time.

To overcome this problem and understand the likely output of the wind farm, it is necessary to look at the amount of electricity generated over a considerable period, usually one year. This will help to ensure that typical weather cycles are accounted for (there are certain times of year which are much windier than others). The amount of electricity generated by a power plant over a given period is easy to measure. Annualising these figures leads to the power output being expressed, for example, in GWh per year or GWh/y. This measured output can then be compared with the theoretical output that would have resulted if the generating plant were able to operate at full power for the full year. This is determined by multiplying the installed capacity by the number of hours in the year (8,760). The difference between this theoretical value and the actual output of the generating plant is known as the 'load factor', or sometimes 'capacity factor'. These numbers are typically over 90% for conventional electricity generating plant and about 25–30% for wind turbine plant, depending on location. It should be noted, however, that load factor can be applied only to the amount of electricity produced in GWh/y, not to the power rating; it is not technically-credible to apply a 30% load factor to the installed capacity of a 100MW-rated wind turbine plant and conclude that on an annualised basis it produces 30MW.

A practical illustration of the need to consider the prevailling weather conditions typical over a long time span is evident in the following statement in the press[14] *"Variability over short time scales has been much discussed, and it is now well known that low wind conditions can prevail at times of peak load over very large areas. For example, at 17.30 on the 7th of December 2010, when the 4th highest United Kingdom load of 60,050 MW was recorded, the UK wind fleet of approximately 5,200 MW was producing about 300 MW… One of the largest wind farms in the United Kingdom, the 322 MW Whitelee Wind Farm [south of Glasgow] was producing approximately 5 MW…".* The incidence of extreme weather events of this type are projected to occur more frequently in coming decades, as a result of climate change induced by past emissions, thereby exacerbating the challenge of reducing future GHG emissions through the utilisation of renewable energy sources such as wind.

SCOTLAND'S CURRENT 'ENERGY BALANCE'

In general, UK energy consumption is divided into three main areas of demand; Heat Energy, Energy for Transport and Electricity. There will be some overlap between these, for example, where electricity is used to provide heating and where a small amount of electricity is used for transport, e.g. for railways. However, these overlaps can be filtered out and the proportion of energy supply which is used to satisfy each field of demand can be accurately estimated. In the UK as a whole, the total energy demand of 1,695 TWh/y in 2008 was split:[15] heat energy 710 TWh/y (41.9%), energy for transport 598 TWh/y (35.3%) and electricity 387 TWh/y (22.8%).

A similarly accurate breakdown of energy demand in Scotland is not readily available within the public domain, though some indicative figures are found in the SRF 'Route Map' of 2006,[16] see **Table 1**; this presents the **likely** energy 'split' for Scotland in 2010 and 2020. On the basis of this split the previous 2020 renewable energy targets of 50% of electricity, 11% of heat and 10% of transport were established (to meet the overall 20% of all energy target).

Table 1. From SRF 'Route Map' 2006[16]

	2010		2020	
Electricity	36.6 TWh/y	(20.3%)	38.4 TWh/y	(21%)
Heat	92.3 TWh/y	(51.3%)	89.7 TWh/y	(49%)
Transport	51.0 TWh/y	(28.3%)	55.0 TWh/y	(30%)
Total	179.9 TWh/y		183.1 TWh/y	

The Compendium[7] states that *"heat accounts for around half of Scotland's total energy use"* (which agrees with **Table 1**) and that the 11% renewable heat target for 2020 equates to 6,420 GWh. From this it can be calculated that total heat energy is about 58,400 GWh/y and therefore total energy demand is about 116.7 TWh/y, considerably less than the figures in **Table 1**. The Compendium also shows that total electricity generation amounts to 51 TWh/y in 2009, which means that electricity would represent about 44% of all energy, which is inconsistent with **Table 1**.

A 2010 set of figures from SRF[6] deviates from those in **Table 1** and shows electricity representing about 32%, heat 43% and transport 25% out of a total of 136 TWh/y. There is thus to-date no consistency in the data for the point of departure for Scotland's future energy policy, and it therefore follows that the achievement of any projected future target will be difficult to measure.

However, regardless of the exact current split between electricity, heat and transport, it is clear that electricity is by far the smallest of the three fields of energy demand in Scotland. Paradoxically it is the future provision of electricity, and the reduction of GHG emissions thereof, that occupys the bulk of energy related Government policy and legislation in both Scotland and the UK as a whole. Consideration of the figures discussed above leads to the conclusion that even if it were possible to fully deliver 100% of Scotland's electricity supply from renewable resources in a robust, secure and reliable manner, this would barely achieve the overall 2020 20% target for energy provision from renewable sources set by the Scottish Government. It follows that much more emphasis needs to be placed on developing the use of renewable energy sources for heat and transport in order to meet the overall renewable energy targets.

SCOTLAND'S 2020 COMMITMENTS FOR ENERGY AND EMISSIONS

Although Scotland is legally bound to meet only the same EU target for renewable energy supply as the rest of the UK, i.e. 15%, the Scottish Government has made its own commitment to achieve 20%.[Footnote 1]

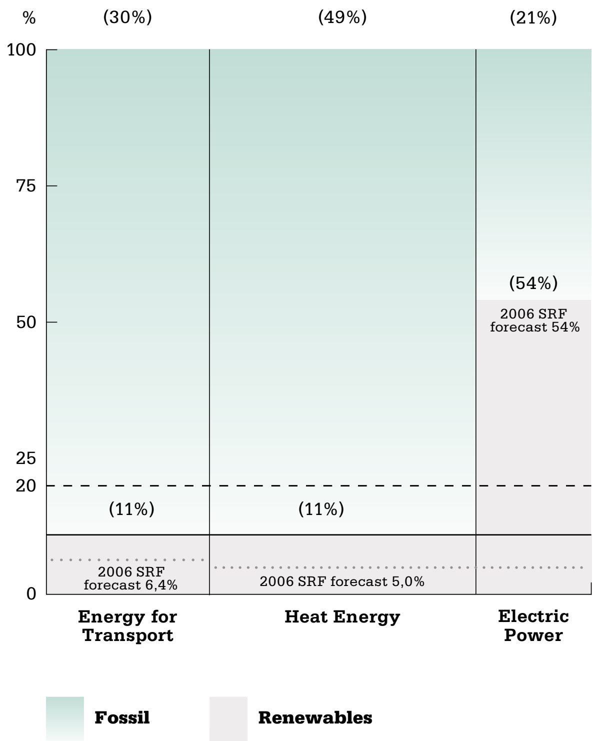
Energy policy in the UK is the remit of DECC and is not devolved to the Scottish Government. In this sense, Scotland does not formally have an independent 'energy policy' for which it can be held accountable. Thus Scotland's legal commitment on the proportion of total energy demand supplied from renewable resources is the same as for the rest of the UK; that is 15%. This figure is not an aspiration, or a well-intentioned 'target', but a binding commitment upon the UK enshrined in the EU Renewable Energy Directive of 2009[3]. It follows that there will be penalties imposed upon the UK for failure to fulfil the commitment by the specified date; though these are not as yet known.

When the previous UK Labour Government came to power in 1997, it set a target for 10% of electricity to be generated from renewable resources by 2010; from a starting point of about 2% (by the end of 2010 this figure was not achieved, the actual share being just 6.9% – little more than two-thirds of the target)[12]. Recognising that Scotland had an existing legacy of hydro-electric power plants, which in 1997 already provided about 10% of its electricity, Scotland was set a higher, though less onerous, target of 18%. The subsequent, far greater, rate of installation of renewable electricity technologies in Scotland than in the rest of the UK meant that by 2009 a figure of about 20% was reached,[6,7] which is very encouraging. Nevertheless, it should be noted that this is a percentage of a lower than anticipated electricity demand in Scotland, largely as a result of the recession, and that in 2009 about half of Scotland's renewable electricity output was supplied from the legacy hydro-electric plants (even though the new one at Glen Doe was out of action for most of the year).

Footnote 1: In June 2011, The Scottish Government raised this 2020 target to 30%[26]

Scotland has substantial potential resources for renewable energy, and partly in recognition of this, the Government has committed itself to exceeding the UK's 2020 commitment. Building on the sector figures given by SRF for energy demand[16], it can be calculated that the proportions to achieve this overall 20% target would be 54% of electricity, 11% of energy for transport and 11% of heat energy to be provided from renewable resources see **Figure 1**. From the very low level of renewable penetration in both heat and transport, and the lack of legislation in place to achieve the targets in these areas, there has to be some doubt as to whether these can be realistically achieved in nine years. Indeed, SRF's own estimates[16] were that 6.4% of transport energy and 5% of heat energy would come from renewables by 2020, and there appears to be no evidence to support higher figures based on present policies.

Figure 1: Scotland's 2020 Energy Mix (based on SRF Route Map)[16]



In the case of GHG emissions, Scotland's targets are a 42% reduction in 'emissions' below 1990 levels by 2020 with an 80% reduction by 2050 (the equivalent numbers for the UK as a whole are 34% and 80%).[4] Achievement of these figures is not solely reliant on reducing emissions in the energy sector, but will depend on a broad range of issues such as how much manufacturing takes place in Scotland rather than abroad, how much waste is recycled in Scotland rather than just exported and whether 'embodied carbon' in imported products is accounted for in Scotland. Furthermore, since a diminishing amount of electricity (and heat energy) will be delivered from nuclear power stations in Scotland, this means that the benefit of the low GHG-emissions characteristics of such plants will be lost, which will have a further impact on achieving the emissions targets. It therefore becomes clear that if a target of 11% of heat and 11% of energy for transport is achieved from renewables, then a full 89% of both heat and transport energy will need to be sourced from fossil fuels; this will have a significant impact on whether the 2020 targets for GHG emissions reductions can be realistically achieved.

CURRENT LEVEL AND TYPE OF 'RENEWABLES' IN SCOTLAND

Despite the sector split in energy demand outlined above, it is difficult to obtain official data showing what types of renewable energy resources are being deployed in which fields.

Although the Compendium[7] is a good source of relevant data, it separates electricity from other forms of energy and does not enable discernment of the penetration of renewables into either heat or transport energy. Thus, despite the fact that these are substantial areas of energy demand for Scotland which are important for emissions reduction and renewables deployment, in the absence of rigorous verifiable data, the rest of this section concentrates on the current position regarding electricity.

The Compendium[7] presents figures for electricity generated in Scotland over the years 2000–2009, in GWh/y, which reveal a heavy dependence on nuclear power. This clearly raises questions regarding how this non-GHG-emitting form of base-load electricity is to be replaced, given the Scottish Government's intention to phase out nuclear generation over the next few years. What is clear is that nuclear power will have to play a declining role in the years through to 2020, as one of Scotland's major stations, Hunterston B, is scheduled to close in 2015/16. Furthermore, the document shows that coal and gas will continue to play a very major role in Scotland's generation mix. This is partly because they are crucial for 'peak-shaving' duty to cater for Scotland's spiky electricity demand. In addition to the loss of Hunterston B however, there is no planned replacement for Cockenzie coal-fired power station, which is also scheduled to close in 2015/16. Ayrshire Power's proposed coal-fired power plant at Hunterston would be the logical replacement, especially if converted to be a combined heat and power (CHP) plant, but this is currently meeting large-scale public resistance and may not proceed. Since intermittent renewables cannot deal with peak-shaving or base-load generation, it is difficult to see how this large proportion of electricity generation capacity can be replaced with renewable sources by 2020.

The Compendium[7] presents data for 2009 that shows the share of electricity generated from renewable resources to be 20% of the total 51TWh/y. However, further analysis shows that this is divided between about 10% hydro and 11% 'other renewables', which, in the absence of contrary information, is assumed to be predominantly wind. That being the case, in 2009 only about 10% of Scotland's electricity came from wind, which is contradictory to the 20% figure often quoted in press and media statements. It is important to note that there are several biomass-fired plants operating in Scotland and biomass is also co-fired at Longannet.

The different types of renewable energy resource available for exploitation in Scotland can be divided into three categories based on their intermittency / predictability characteristics:

1. Intermittent, unpredictable resources such as wind, solar and wave;
2. Intermittent but fairly predictable resources such as tidal;
3. On-demand, predictable resources such as biomass, energy from waste and geothermal.

The simplest renewable energy policy would be to supply most energy from **(3)**, the 'on-demand' resources. This is because these technologies most closely resemble the traditional way of producing power and heat in developed countries. However, they generally involve finite resources, the use of which may or may not be sustainable, and have an operational cost as well as capital expenditure component.

Wind, wave and solar energy are in category **(1)** and the most difficult types of renewable to integrate into a consumer-demand-driven national system. The wind blows, waves heave and the sun shines at times which do not necessarily match consumers' energy demand. For example, a solar thermal system will rarely produce hot water in the winter season when it would be most useful. Yet the intermittent resources available to use are attractive because they come at little or no operating cost and should in the long-term lead to less expensive and more sustainable provision of energy in all its useful forms. To enable this will require the deployment of suitable energy storage devices, which at present are in the very early stages of technical development and unlikely to be available before 2020. It is evident, therefore, that an energy policy to 2020 which is heavily reliant on wind, wave and solar resources, will not meet the current pattern of energy demand without significant back-up capability from other resources which, in the absence of nuclear new build, will need to be in the form of fossil fuels. Given the uncertain future of CCS, this is not an attractive outcome for emissions reduction planning.

Beyond wind, wave and solar there is considerable potential in Scotland for exploitation of the nation's abundant tidal resource. Indeed, the Institution is positively supportive of the development of marine renewable devices[17] in Scottish waters. However, although these technologies are in category **(2)** and operate in a more predictable manner than wind, wave or solar, there will be times when power production coincides with peak energy demand and times when it does not. In the absence of deployable energy storage devices with significant capacity, this again will demand a similar source of back-up energy to that described above. The advantage of these technologies is, however, that the time phase to be covered will be a matter of hours and therefore easier to accommodate. In the case of wind, wave and solar, back-up devices may have to operate for several days (or even weeks) rather than a few hours; for example, at times of high atmospheric pressure and low wind speeds.

Energy from Biomass, Energy from Waste (EfW) and Geothermal (both naturally occurring hot springs and 'hot rocks') technologies fall into category **(3)** and are different from those mentioned above, in that they can usually supply electricity on demand, i.e. are not intermittent; they are also all capable of additionally providing heat energy. Furthermore, they not only do not require back-up themselves but are able to provide back-up for intermittent renewable sources. The deployment of these technologies does, however, in each case have particular issues, for example related to land-use and feedstock security in the case of biomass and waste.

The discussion above clearly illustrates that a credible and sustainable energy policy has to be based on an understanding of the energy supply technologies, not on the basis of political expediency. Modern industrialised and post-industrial economies are underpinned by easy access to abundant sources of low-cost energy. Any government or political party, in today's world, needs to have an energy policy which is entirely credible.

CURRENT POLICY THINKING

The Power of Scotland Renewed paper,[5] published by various NGOs in 2009, suggests that a largely renewable energy future for Scotland is within grasp and this perception appears to have influenced both public and Government thinking on the future of Scotland's energy provision. Indeed the paper was referenced by the [Glasgow] Herald in a recent article discussing the '100% renewable electricity' debate[20] as showing that "Scotland could comfortably meet 100% of electricity demand from renewable sources by 2020." However, a careful review of the document reveals some important inconsistencies and errors, for example:

1. **Inherent contradiction.** The report claims on page 1: "Given that the power generation sector is the largest single source of carbon dioxide…"; it further claims on page 10: "Electricity generation is responsible for only a small proportion of energy related greenhouse gas emissions. Transport, and to a greater extent heat, make up the majority of Scotland's greenhouse gas emissions." Clearly, these are diametrically-opposed views.
2. **Idealistic solutions.** None of the technical issues raised in this Institution report have been addressed in the five scenarios presented in the paper, which does not provide a practical workable approach for providing a more sustainable energy future for the country. In particular, the need for large amounts of back-up generation capacity to support the deployment of intermittent renewables on the scale proposed appears to have been largely ignored.
3. **Inaccurate trends.** The paper states on page 5: "The overwhelming bulk of the reduction in large-scale generation was in the nuclear sector – its share of electricity generation fell from over 33% in 2000 to 25% in 2007." Data presented in the Compendium shows that in 2009, 33% of electricity in Scotland was generated from nuclear, so there was virtually no change over the decade.

Although the Power of Scotland Renewed paper has contributed significantly to current thinking in Scotland, these inconsistencies, combined with the fact that a credible scenario is not presented, mean that it cannot provide a basis for the nation to deliver its ambitious 2020 targets.

REVIEW OF THE BARRIERS TO SCOTLAND ACHIEVING ITS 2020 TARGETS

Many of the Institution's members work in the energy sector and are critically involved in delivering the machines, equipment and devices which will be necessary to meet the 2020 targets. In reviewing the practical issues related to achieving a successful outcome the following points can be made:

1. **Technology issues:** A number of technologies used in renewable energy systems have been around for a long time, a good example being wind turbines. Nevertheless, significant development work is still taking place even on such well-known technology to improve efficiency, performance and maintenance, simplify manufacture and reduce costs. Furthermore much design, testing and demonstration work remains to be done to enable offshore deployment, particularly in deep waters. Many believe that Scotland's future in renewable energy lies with marine devices, but the fact remains that there is a great deal of expensive and time-consuming RDD&D work ahead before these devices are available for deployment in large quantities at a meaningful scale.

   To support increased use of renewable sources of energy, substantial technology needs to be developed in the areas of smart metering and smart grids, and even more crucially in energy storage. Advances in the latter have been slow to materialise and there are still no readily-available systems on the market. Until such devices are available, reliable and cost-effective, it is difficult to see how high percentages of intermittent electricity generation can be incorporated into Scotland's national transmission and distribution system without serious disruption.

2. **Infrastructure issues.** The National Grid system built in the UK was originally designed to connect large, centralised, electricity generating plant to the main industrial users, e.g. in the Scottish case located in the Central Belt. This situation has changed significantly and the grid is now required to connect increasing numbers of remote power generators using local renewable sources to a much more diverse consumer base. Furthermore, much of the grid asset is reaching the end of its design life and requires updating. A multi-billion pound investment is needed in order to tackle both of these issues and make this infrastructure fit for purpose in the new energy regime.

   In addition, the grid connection between Scotland and England is currently used to export up to circa 2GW of excess power from Scotland to England (mainly from Scotland's nuclear power stations) and may, in the new regime, need to be substantially upgraded to be able to provide the necessary back-up power from England to Scotland to support the large anticipated intermittent renewables sector in Scotland.

   Furthermore, in the case of heat energy applications, there is no significant, available delivery network in Scotland and little thought appears as yet to have been given to this issue. Biomethane-to-Grid (BtG) is being considered as an option, but there will be a 'wait-and-see' period, probably of several years, to try to learn from German and Swedish experiences. It is however important to note that the 'clean-up' technologies to convert the highly-contaminated biogas to 'grid-quality' methane are not yet tried, proven and cost-effective.

3. **Skills issues.** Even if it were possible to resolve the technology and infrastructure issues in the short time period to 2020, there are still major concerns in the engineering community regarding Scotland's ability to provide the human resources necessary to design, project-manage, install and commission the volume of equipment that will be required to meet such ambitious targets.[21] Some sources have suggested that to achieve the 2020 targets, the number of skilled engineering-sector personnel will have to increase between fivefold and tenfold over the next ten years;[22] this set against a context where many of the limited training places offered in the UK for MScs and PhDs are going to overseas students, who then return to their home countries.

   One strategic approach to this challenge might be to assume that appropriately-trained people from overseas will be able and willing to work in the renewable energy sector in Scotland. However, many countries across the globe are also aiming to meet challenging renewable energy targets over the next few years, and it is by no means certain that such people could be attracted to work in the sector in Scotland rather than elsewhere. There appears to be no credible evidence that the skills base necessary to support the Government's Manifesto[23] pledge of the creation of 130,000 jobs in the 'green' energy sector in Scotland is achievable over the next nine years.

4. **Manufacturing capability issues.** As is well documented, over the past 30 years Scotland has declined from being a major engineering/manufacturing centre to having a relatively low capability-base today. Although Scotland is by no means devoid of manufacturing industries, the country does not have a nearly sufficient manufacturing base for the large volume of equipment which will be required to meet the 2020 targets.

   A further challenge to delivery is that there are few manufacturing companies in Scotland making renewable energy equipment. The companies manufacturing sub-structures for the offshore wind industry are doing well and their contribution is extremely valuable, but the equipment they are making is not 'renewable energy' equipment and the description of these as 'green jobs' is rather tenuous. Renewable energy equipment remains the province of overseas manufacturers. Even the wind turbine tower manufacturing facility in Machrihanish has struggled to stay in business,[24] despite the enormous number of wind turbines which are forecast to be installed in Scotland over the coming years.

   A successful manufacturing base would be provided by a combination of large corporations and SMEs. Large corporations will invest in new manufacturing capacity in Scotland only if the market conditions are right; this is particularly true of overseas companies without current facilities in the country. SMEs, on the other hand, particularly those making specialist components as part of a supply chain, are much more likely to want to be able to set up manufacturing facilities in the country, but find the regulations and legislation they have to cope with too daunting. There is a clear role for Government to actively encourage and assist SMEs to take on the manufacturing roles that are required to support the 2020 objectives.

5. **Funding issues.** In the current financial climate, SMEs are finding it particularly difficult to access the finances necessary to build their businesses so as to be able to provide the goods and services required to meet the 2020 targets.[21] Large renewable energy projects, in particular offshore wind, can be funded by multinational corporations (MNCs) from their own balance sheets, and there is often no need for them to seek external funding. Whereas SMEs, along with local communities, do not have an equivalent finance base and must obtain funding from external sources for smaller-scale projects and/or manufacturing equipment. Sources such as banks typically require at least 100% security for any loans advanced, which normally takes the form of charges over the homes of the people looking for the loans. In addition, high rates of interest and high bank charges are applied to any loans given. Other investors find the sustainability criteria which underpin the renewable energy sector inconsistent with high profits and tend to avoid the sector. These issues have the effect of making business opportunities unattractive and therefore stifle an expansion of the renewable energy equipment manufacturing base in Scotland.

   Government has an important role to play here in restructuring the Scottish economy and ensuring that SMEs working in the renewables sector can gain access to the finance they need.

FUEL POVERTY IN SCOTLAND

The 2003 UK Energy White Paper[25] made 'fuel poverty' one of its four main policy objectives (along with reduction of CO_2 emissions, reliability of energy supply, and maintenance of competitive markets). While none of these objectives has yet been reached it is clear that, rather than improve, fuel poverty has actually worsened over the period since 2003.

The broad definition of fuel poverty is the inability to heat a home to an acceptable standard at a reasonable cost. The Scottish Government's definition is: "a household is in fuel poverty if, in order to maintain a satisfactory heating regime, it would be required to spend more than 10% of its income on all household fuel use. Extreme Fuel Poverty is defined as being required to spend 20% of income on fuel to maintain an adequate heating regime."[7]

"The Scottish Government has pledged to ensure that by November 2016, so far as is reasonably practicable, people are not living in fuel poverty in Scotland."[7]

The Compendium[7] presents data that shows the fuel poverty rate in Scotland fell from 35.6% in 1996 to 13.4% in 2002. However, from that point, fuel poverty has been steadily rising, year-on-year to 32.7% of households in 2009 – almost back to the 1996 levels. Although in recent years this may be a result of increased fuel prices being only partially offset by rising incomes and energy efficiency increases, the figures reveal that fuel poverty was rising sharply well before the current economic recession began in the UK.

The data presented in the Compendium also shows that households in 'extreme fuel poverty' were 8.6% in 1996, falling to 3.2% in 2002 and rising again to 10.3% in 2009.

These figures are considerably higher than for the UK as a whole, but are also substantially in excess of the European average, where just 8% of households were inadequately heated in 2009. Scotland clearly has a particular problem in this area which is not being adequately addressed. To achieve a zero fuel poverty target by 2016, with fuel poverty forecast to continue to rise over the next few years, will be a very major challenge, especially with the various market incentives for renewable energy inevitably contributing to higher energy costs.

10.3% OF HOUSEHOLDS IN SCOTLAND ARE CLASSED AS BEING IN 'EXTREME FUEL POVERTY'.

SUMMARY AND CONCLUSIONS

This report has presented a practical engineering view of the key issues and challenges to be addressed, if Scotland is serious about achieving the ambitious targets which it has set itself for the exploitation of renewable energy sources by 2020. From the analysis presented, it is clear that without substantive and far reaching changes in Government policy, the target will not be met. This is for a number of reasons:

1. The Scottish renewable energy announcements are not SMART:

Specific – The targets have been set as percentages (i.e. relative values) which, since the starting point is unknown, are not specific. There are no agreed published targets in absolute terms, e.g TWh/y, for either overall energy supply/demand or its component parts. Further, established consistent data on current energy supply/demand, other than for electricity, is not available in the public domain. Without such information, percentages cannot be described as 'specific'.

Measurable – In the absence of an agreed starting point, it is not possible to measure the changes that would enable the percentage calculations. Not only does a credible energy policy require a clear starting point and a clear end point, it is important that progress can be measured at 'milestones' over the period for which the target is set.

Achievable – From an engineering perspective, if a target is not achievable there is no point setting it. This report has revealed that there is no practical strategy in place to ensure that Scotland will achieve its renewable energy target by 2020 (or its highly ambitious 100% renewable electricity target). Given the significant barriers that need to be urgently overcome, and the large number of wide ranging issues requiring timely resolution, it is doubtful that the present level of activity and commitment are sufficient to actually achieve the targets.

Realistic – For a target to be realistic, it has to be founded on factual data. In the case of a target for exploitation of sources of renewable energy, this translates to a comprehensive engineering based technical assessment of the means by which the target can be realistically met. It is not apparent that any such study has been considered in setting the present renewable energy aspirations for Scotland, as there is no comprehensive engineering assessment in the public domain which would support the targets which have been announced.

Time-based – Any project needs to be bound by time. In this case, the time limit is very clear, December 2020. The track record to-date in Scotland is that about 6 TWh/y of electricity was generated from 'new' renewables (i.e. not legacy hydro = 4.8 TWh/y) over the past decade, approximately 4.7 TWh/y of this from wind and 1.3 TWh/y from all 'other' renewable sources. If 'gross electrical consumption' is taken as 39.2 TWh/y, then the previous 80% target equates to 31.4 TWh/y and the 100% target to 39.2 TWh/y. Given that almost all of the new installed capacity to 2020 will be on-shore and off-shore wind, this means that new capacity will have to be installed at about four times the rate of the past decade to numerically achieve the 80% target, and more than five times the rate, if the 100% target is to be achieved. Given the barriers to implementation discussed above, and the fact that the best sites for onshore wind have already been taken, plus there is, as yet, no data or meaningful experience from offshore wind in the Scottish North Sea, it is not clear from an engineering perspective how this installation rate will be achieved through current policies.

2. Present policies have little to say regarding the requirement for back-up generation capacity to support Scotland's intention to source substantial amounts of power from intermittent renewable energy sources. In the absence of such policies, with the demise of conventional power plant in Scotland, the nation will likely become a net importer of electricity received through grid connections with England and Northern Ireland (thus reversing the current situation in which Scotland is a net exporter of electricity which is transmitted through the national grid connections). However, it is important to note that England and Wales will, through the closure of life-expired conventional power stations, experience a similar reduction in electricity generating capacity to Scotland over the period to 2020, so the electricity may need to be imported from Continental Europe.

3. There is an inherent problem in trying to achieve the overall target for all energy from renewables largely by electricity. Electricity is the smallest component of energy demand in Scotland, whereas heat is by far the biggest, and transport energy needs fall between the two. It would be technically remiss to assume that the renewable heat and transport targets can be reached by a shift of these sectors to electricity. Electricity is an inefficient way of providing heat, even using heat pumps instead of direct heating, and runs counter to the Energy Hierarchy.

RECOMMENDATIONS FOR A SUSTAINABLE SCOTTISH ENERGY POLICY

While the Institution of Mechanical Engineers fully supports the desire of the Scottish Government to maximise the enormous potential for renewable energy that exists in Scotland, this aspiration must be moderated by a pragmatic, 'real world' approach to what can actually be realised. Even within the power generation sector, a relatively straightforward area compared with heat and transport energy, the ability to achieve large percentages of electricity supply from 'intermittent' renewable energy resources is technically challenging in both engineering and policy terms. As a starting point towards a successful outcome for Scotland's renewable energy exploitation project the Institution makes the following recommendations.

1. The Scottish Government should, as a matter of absolute priority, establish, agree and publish the current position in TWh/y of the gross energy consumption in Scotland in the three component fields of heat, transport and electricity. It should then determine its targets for 2020 (on SMART principles) in the same three fields. The inter-relationship between these three fields must be clearly understood and their relative positions in the 'energy mix' defined and made publicly available. Only clearly-defined targets can be intentionally achieved.

2. If the present target of 100% electricity from renewable energy sources by 2020 is to be maintained, then the Scottish Government should clearly state its engineering-based methodology for achieving this ambitious target without delay. Until a clear methodology exists, the targets are only an aspiration. In this regard Government should consult, without delay, with competent and independent engineering professionals who have knowledge and experience of the actual delivery of major power projects, to establish what level of electricity generation from renewable energy sources can realistically be built in Scotland and in what time period. This will involve determining the skill levels, manufacturing capability and planning obstacles, as well as the numerous outstanding technology and infrastructure issues that still need to be resolved.

3. That the Scottish Government prioritises the sourcing of secure, reliable energy supplies for the nation's electricity, heat and transport requirements, while effectively tackling the growing issue of fuel poverty. The latter must be addressed within Scottish energy policy to ensure that an increasing number of people are not tipped into fuel poverty simply because of the increased cost of providing renewables based energy; such an outcome would create an unsustainable position for the Scottish people.

CONTRIBUTORS

The Institution of Mechanical Engineers would like to thank the following people for their assistance in developing this report:

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Whitelee image (p18) courtesy of Rick Bolton.

REFERENCES

[1] www.energyefficiencynews.com/i/4109

[2] **Green Energy Target is a 'Nonsense'**, PE Magazine, May 2011 (Caspian, London, 2011).

[3] **EU, Directive 2009/28/EC of the European Parliament and of the Council**, 23 April 2009. Available at www.europarl.europa.eu/oeil/file.jsp?id=5589632

[4] www.guardian.co.uk/environment/2009/jun/24/scotland-climate-change-bill/print

[5] **The Power of Scotland Renewed** (FoE, RSPB, WDM & WWF, 2009) Available at http://assets.wwf.org.uk/downloads/powerofscotland_renewed.pdf

[6] **Rachelle Money, Scotland's Renewable Target Lifted to 80% by 2020** (Scottish Renewables Forum Review, Issue 71, Autumn 2010).

[7] **The Scottish Government, Energy in Scotland: A Compendium of Scottish Energy Statistics and Information** (The Scottish Government, December 2010). Available at www.scotland.gov.uk/Resource/Doc/933/0110153.pdf

[8] **The Scottish Government, Renewable Heat Action Plan for Scotland** (Scottish Government, November 2009). Available at www.scotland.gov.uk/Publications/2009/11/04154534/0

[9] **DECC, Energy Trends**, December 2010. Available at www.decc.gov.uk/assets/decc/Statistics/publications/trends/1083-pn10-133.pdf

[10] **DECC, Energy Trends**, September 2011. Available at www.decc.gov.uk/en/content/cms/statistics/publications/trends/trends.aspx

[11] **IMechE, The Energy Hierarchy**, Energy Policy Statement: 09/03 (Institution of Mechanical Engineers, London, 2009). Available at www.imeche.org/Libraries/Position_Statements-Energy/EnergyHierarchyIMechEPolicy.sflb.ashx

[12] **DECC, Energy Trends**, March 2011. Available at www.decc.gov.uk/en/content/cms/statistics/publications/trends/trends.aspx

[13] www.scotland.gov.uk/News/Releases/2010/09/23134359

[14] **Utility firm reports alarming drop in renewable power output, Your Renewable News**, 04 February 2011. Available at www.yourrenewablenews.com/utility+firm+reports+alarming+drop+in+renewable+power+output_59085.html

[15] **HM Government, the UK Renewable Energy Strategy**, July 2009. ISBN 9780101768627

[16] **SRF, Delivering the New Generation of Energy – Route Map to Scotland's Renewable Future** (Scottish Renewables Forum, 2006).

[17] **IMechE, Marine Energy – more than just a drop in the Ocean** (Institution of Mechanical Engineers, London, 2009). Available at www.imeche.org/Libraries/Position_Statements-Energy/MarineEnergyIMechEPolicy.sflb.ashx

[20] www.heraldscotland.com/news/election/snp-s-100-green-aim-is-a-fantasy-1.1096491

[21] **Ian Arbon, Scotland's Struggle**. Holyrood Magazine, 14 June 2010 (Edinburgh, 2010)

[22] Ian Arbon, personal communication, October 2011

[23] **Scottish Manifesto**, including pledge on 130,000 green jobs http://votesnp.com/campaigns/SNP_Manifesto_2011_lowRes.pdf

[24] http://computescotland.com/vestas-to-close-turbine-plant-at-machrihanish

[25] **DECC, Our Energy Future: Creating a Low-Carbon Economy, Energy White Paper 2003**. Available at www.decc.gov.uk/en/content/cms/legislation/white_papers/white_paper_03/white_paper_03.aspx

[26] Fergus Ewing, June 2011-10-25

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