The Institution of Engineers and Shipbuilders in Scotland

"Efficient use of Energy"

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***Abstract* – World energy demand is projected to grow by more than 50% by 2030.[21] Improving energy efficiency is one of the most economical and short to medium term ways Scotland can reduce its dependence on fossil fuels and reduce its emissions of greenhouse gases. Transportation and buildings, which account for two thirds of energy usage [16], consume far more than they need to, but even though there are many affordable energy efficient technologies that can save consumers money, current utilisation is small. To overcome this, the government must adopt policies that invest in research and development programs that target energy efficiency. Incentives schemes if properly implemented can stimulate and encourage energy efficiency which is one of Scotland's great hidden energy opportunities. This paper outlines the position of the Institution of Engineers and Shipbuilders in Scotland and makes recommendations for the Scottish Government by two separate means of improving energy efficiency; reducing wastage and providing the same end need using less energy.**

Introduction

Impetus is turned to energy and its efficient use often only after turbulent world events. The OPEC oil embargo in 1973, the overthrow of the Shah of Iran in 1979, the Gulf War in 1991, the invasion of Iraq in 2003 and the current global economic downturn highlight examples when serious attention has turned to energy policy. Historically however the majority of energy efficiency initiatives lost momentum and policy reverted to exploitation of existing resource's much as we do today. Scotland faces a greater energy risk today than it has at any time in its history. Global warming and the potential it has for causing major disruptions to Earth's climate are scientific realities and compound the energy problem Scotland faces today.

The precise extent of the human contribution to global warming still needs deeper understanding, but there is virtually no disagreement among scientists that it is real and substantial. In theory, there are three ways to reduce greenhouse gas emissions: reducing economic growth, changing the energy mix to low-carbon sources, and increasing energy efficiency.

This paper considers the third option .The EU has now committed itself to a 20% cut in greenhouse gas emissions by 2020 (relative to 1990 levels) and to a 30% cut in the event that other blocs are prepared to make similar commitments. The Scottish Government has set a target of reducing greenhouse gas emissions by 80 per cent by 2050. [3] The UK identified the actions required to meet the Government's aspiration for a 60% reduction in carbon emissions by 2050, as outlined in the 2003 Energy White Paper [16]. Globally if we consider again that over the last 35 years the U.S. has doubled it's importation of oil, two of the worlds most populated countries, India and China, have moved from rural agricultural based economies to heavily growing industrial superpowers with large energy needs and the threat to energy security has changed largely from several countries to international terrorist organisations. Oil prices are subject to large fluctuations, increased transportation costs are driving up the costs of goods, and home heating oil is becoming expensive. There is public concern at the cost of energy. In contrast to previous economic downturn there is opinion that this period will be steeper and longer lasting. On current projections, world CO2 emissions will increase by more than 50% by 2030 [21].

It is with this background that this paper proposed by IESIS in conjunction with other IESIS Energy position papers [Ref], attempts to align a sustainable strategy for Scotland to allow competitiveness in difficult trading conditions whilst meeting our International commitments, some of which are currently unclear and/or undecided.

Definitions

It is important to separately define energy efficiency and energy consumption at this point. Energy efficiency is the ratio of the energy extracted from a fuel to the total amount of energy available in that fuel. Energy consumption is slightly different and means reducing the absolute amount of energy used for any purpose. These might seem intuitive definitions at this point, but [3] suggests that energy efficiency and energy consumption need much more careful definition so that they can be measured and monitored in an objective manner. The Institution of Mechanical Engineers has graded the above categories as the top two priorities in its position paper on Energy. [1]

This paper will consider improving efficient use of energy, improvements in energy efficiency, reducing energy demand whilst first considering human behaviour towards energy efficiency and the drivers of energy efficiency.

Human Behaviour Towards Energy Efficiency

One of the biggest obstacles to energy saving is human behaviour. The need for education of not only the public but of business that energy saving is so strongly in their own interests that it is essential to change behaviour. It is not easy to bring about changes in human behaviour particularly in a democratic society. Economists often argue that improvements in energy efficiency effectively reduce the price of energy and as a result stimulate increased economic growth and increased energy consumption [27]. This is at variance with the UK Energy White Paper of 2003 and in the UK Energy Review consultation paper of 2006. The cheapest, cleanest and safest way of meeting the 2003 White Paper targets could be through using less energy rather than trying to cope with the effects of using more energy. Expert analysis has shown that business and consumers waste about 20% of Scotland's total energy spend each year, representing £1.3 billion in resources lost to the Scottish economy on energy alone (Scottish Executive News 7/12/2004). The UK House of Lords Committee [12] believes that Government has yet to engage with complex behavioural issues. The IESIS believe that only through education and financial incentive will suppliers and end users adopt behavioural change. The Tyndall Report, [10], indicates that a true 60% reduction in carbon emissions is achievable by 2050 but major behavioural hurdles must be overcome if this is to be achieved.

Scotland is a small country and only produces 0.2% of the world's greenhouse gas emissions. This is certainly not a reason for Scotland's legislators to drive change.

"Just as the unconstrained free-thinking of the enlightenment here in Scotland helped deliver the modern world, truly radical free-thinking is now required to deliver a prosperous future for all." [9]

The IESIS consider that the level of current research and development programmes needs to be supported and extended if Scotland can produce energy saving to yield economic benefit and conserve fuel stocks. Furthermore the IESIS supports a substantial transfer of technology from industrialised to industrialising countries to realise the more than 70% of the world's energy-saving potential in developing countries [2]. Although much remains to be done in Europe, compared with other world regions it is very energy-efficient. If all countries in the world had Europe's energy productivity rate, then the world's energy consumption would be instantly reduced by more than a quarter. [2] Scotland and the EU's external policy must make this a priority and stimulate voluntary technology transfer to outside Europe.

IESIS consider that greater effort should be made through education programmes, not only in schools and higher education but throughout the business community. At present, there is a great variety of schemes and initiatives devised by Government to encourage responsible use of energy, but as there is a small take-up of these schemes more radical approaches should be considered. For example there should be a roll-out of energy efficiency labelling, currently displayed on some domestic electrical goods and cars, to cover all energy using devices and buildings.

Drivers of Energy Efficiency

If consideration of the drivers towards increased energy efficiency and energy savings is given it is necessary to accept that the use of fossil fuels, are now known to contribute to pollution of the environment and have a profound effect on global climate change.

IESIS is an advocate of finding ways of cutting this pollution before it has an unacceptable or irreversible effect. Much of our interest in energy efficiency is therefore inextricably linked to reductions in emissions of greenhouse gases which are known to be contributing to global warming and climate change.

Having considered human behaviour, Scotland must look firstly inward to action; combating global warming requires global collective action and will take decades to have an impact. Scotland can still take an enlightened radical approach that by assisting, our developing neighbours, Scotland can impact on a much greater amount of the GHG's than our own 0.2% of the world's greenhouse gas emissions. Carbon dioxide is thought to have a 'residence time' of around 100 years. CO2 accounts for some 80% of the total GHG emissions in the UK, and the energy sector is responsible for around 95% of these [24].

As many of the sources of non-renewable energy we currently use are clearly finite it must be through large scale research and development that Scotland can discover new energy sources or technologies which make us less dependent on these finite sources. If the rate of energy consumption can be slowed, the finite sources will last longer and buy time till alternatives are viable. To achieve this IESIS support steps to improve the efficient use of non-renewable energy resources and exploit the opportunities to make savings in the energy consumed.

Often successive governments are constrained to take a 4 year, (term of office), view on policy, this is unsatisfactory in terms of energy planning. IESIS would consider energy security and also the decades to reduce greenhouse gas levels in the atmosphere to arrest levels of global warming a duty of care to any incumbent administration.

There are no technological barriers to using less energy now. Typical means of achieving energy efficiency and energy saving are considered in the coming sections but as a driver to energy efficiency it has to be pointed out that they are already available but are not being fully exploited.

The Tyndall Report [10], states that, from the point of view of long-term sustainability, low-energy scenarios are preferable to scenarios with a high energy demand. Energy saving and efficiency can therefore contribute to a sustainable future. Energy efficiency, up to 40% savings, could be achieved in a cost effective fashion and is the subject of a range of studies (e.g. Imperial College for the Carbon Trust, PIU Report). If Scotland is to achieve greater energy security by reducing it's reliance on fossil fuels, to sustain strong economic growth in the face of worldwide competition or to reduce global warming by decreasing carbon emissions, energy efficiency is where Scotland needs to begin.

Reducing Energy Use and Waste

Reduction in energy consumption is the cleanest way of making new energy available, since it does not contribute to emissions of global warming gases, release of pollution to soil, water or air or increase in area utilisation. In addition, initiatives will often be more cost-efficient than production of new fossil / renewable energy, because reduced energy consumption does not demand investment in new infrastructure or the delivery net. The potential for this is enormous but consider some typical examples where this can be applied.

A recent McKinsey study, conducted for the German economy, finds considerable untapped potential in cost-effective energy efficiency measures, especially for the residential sector - almost 60 million tonnes of CO2 by 2020. [4] Implementation and enforcement of existing legislation relating to energy efficiency, which will already provide a substantial part of the energy savings. 40% of the EU's energy consumption comes from buildings yet despite the existence of EU requirements to improve energy efficiency in this sector, lack of implementation at national level are slowing down much needed progress. [15] Further significant savings in energy and carbon emissions are possible, for example that the super-insulation of dwellings could result in savings in heat energy of up to 80%. In Australia, 83% people who drove to work or study in 2003 did not have a passenger. (ABS Social Trends, 2003). In the USA, single occupant commuting is around 75% according to census data.

Domestic energy consumption in the UK in 2004 was responsible for approximately 30% of total UK energy use and approximately 27% of total UK carbon dioxide emissions (HM Government, 2006). This energy is used for space and water heating, cooking, lighting and electrical appliances, with approximately 53% of household carbon emissions being due to space heating, 20% due to water heating, 22% due to lights and appliances. [28] More journeys are made by bike by the 16 million inhabitants of Holland than are made by all English speaking countries put together.

There is large potential for home and remote working: 65% of people in recent working practices report responded that they would work from home if they could. [26] The availability of remote I.T facilities to not only reduce local (commute) travel, but with international travel leaves a large potential with correct incentive scheme application. So called teleworking eradicates energy used on journeys.

The Scottish Government should consider measures, such as the use of pooled lanes to encourage higher occupancy in private vehicles. Bus and Rail transport operators should be given greater support to operate a wider range of routes to cope with variable passenger loads.

IESIS supports a smarter approach to education and incentives to users who implement behavioural changes that reduce the consumption outlined in the previous sections.

Reductions in demand can be achieved in various ways:

• energy reduction in the design of new consumer products.

Improving Energy Efficiency

Energy Efficiency Associations have sought the EU to adopt a mandatory measurable target for improving energy efficiency of 20% by 2020 to signal the importance of energy efficiency measures for security of energy supply, economic growth and environmental protection. The associations have stated the technology, resources and ability to deliver sustained improvements in energy efficiency exist across the EU. [13]

Energy inefficiencies can be introduced at any point during acquisition, generation or distribution of energy. This is even before considering the end user inefficiencies in products or even human behaviour. Energy efficiency should figure more prominently in the European Strategic Energy Technology Plan, since it is the area with the most potential for cost effective emission reductions in the medium term. [20] The areas for possible consideration are extremely diverse. However as an indicator if consideration is given to some examples in the Built Environment, Power, Transportation and Industry, the scope of potential becomes very evident.

Built Environments

The building sector represents around 40% of all CO2 emissions in the EU. The European cement sector is engaged in a long-term policy of reaching carbon neutrality of concrete as a building material. Intelligent combinations of heating, ventilation, solar shading and building structure can reduce energy use by up to 50%. Use of advanced insulating glass units. Replacing one m2 of single glazing by low-E double glazing saves 91 kg of CO2 per year. Lighting consumes 14% of all electricity within the EU. Approximately, two thirds of all lighting currently installed in the EU is based on older, less energy efficient technology, developed before 1980. Philips has developed the Green Switch programme, which accelerates the change over through greener lighting technologies through education and information campaigns and liaising with policymakers.

Performance in Scotland in energy efficiency in existing buildings and designing energy efficiency into new buildings falls well below best practice in other countries. Scandinavian and German buildings are considerably more energy efficient than those in Scotland.

The energy efficiency of both existing houses and new build needs to be improved. Raising building standards in Scotland to the level of those in Scandinavia and Germany could save 20% of domestic energy consumption. New buildings should be credited in tax banding if they adopt low and zero carbon building integrated energy generating technologies such as wind turbines or solar panels; using condensing boilers etc. There is a need to encourage the replacement of equipment with appliances that are increasingly energy efficient and that combined heat and power, particularly with apartment buildings. The EU Directive on the Energy Performance of Buildings 2002/91/EC requires that whenever a building is constructed, sold, or rented out, a certificate detailing its energy performance must be made available. Enforcement of Building Regulations in relation to energy efficiency needs to be implemented.

Power

A quarter of all global greenhouse-gas emissions come from the generation of power and heat, which is mostly used in domestic and commercial buildings, and by industry. The greatest loss of energy is in the generation of electricity. Almost two thirds of the energy content of the fuel is dissipated as unused heat into the atmosphere. Further support to Scottish initiatives such as the work at Strathclyde University Energy Institute should be given to assist this. Obvious areas are the reduction in the transmission loss in the electricity grid, and especially in distribution to consumers, reduction in the loss of heat and other energy in the generation of electricity, energy saving devices such as smart meters to require less energy input for the same output..

Efficient electricity generation from coal. There is a plant in Denmark which has the highest electrical efficiency from a coal-fired installation to date. Coal is used 20% more efficiently than at older coal-fired plants, corresponding to 20% less CO2 emissions. The plant can achieve 47% thermal efficiency. Further, advanced clean coal technologies are used at the plant, significantly reducing emissions of SO2 and NOx.

Residual gas produced in the oil fields in Nigeria (that was previously wasted by flaring it) is used to produce electricity in a power plant, which accounts for 12% of the overall generation capacity of Nigeria.

Using municipal waste for energy. Cement kilns in Italy substitute 20% of its energy needs for clinker production with high-quality solid recovered fuel from local municipal solid waste. Thus more than 70,000 tonnes of CO2 are saved per year and the total amount of solid waste locally generated by the population is fully recovered. This is but one example of co-processing: the average substitution rate of traditional fuels at cement plants in Europe is around 20%.

The Energy Saving Trust (2007) has estimated that, by 2020, consumer electronics and ICT will account for around 45% of domestic energy use. [17] Energy efficiency labelling is required and Internet companies reducing the energy use of the routers and servers that consume large amounts of electricity.

Transport

According to the International Energy Agency, the amount of CO2 released by the transport sector accounts for 23 percent of global warming emissions, a figure that is topped only by the electric power generation and building heating sector. International coordination to tackle the reduction of CO2 in the transport sector has been described as urgent because the amount of CO2 emitted by the sector looks set to double in 20 years as economic growth in emerging nations leads to increased car ownership.

On average, passenger rail currently emits approximately half the carbon dioxide per passenger kilometre of cars and around a quarter that of domestic air. Since 1995/6, passenger rail has improved its position substantially: average emissions per passenger km falling by an estimated 22% compared to an 8% reduction from car traffic and a 5% increase from domestic air.

20% of the energy used to move a car is consumed by tyres. Tyre rubber compounds transform energy into heat when the tyres are in motion. Michelin has been working for more than 80 years to reduce this so-called tyre rolling resistance, and the introduction of silica in 1993 was a major breakthrough. Low rolling resistance tyres now represent about 50% of passenger car tyres sold in Europe on the replacement market. However their market uptake is slower than expected, because many consumers are not aware of environmental impacts when purchasing tyres.

Three-quarters of these emissions are from road transport, while aviation accounts for around one eighth and rail and shipping make up the remainder. Total CO2 emissions from transport are expected to more than double in the period to 2050, making it the second-fastest growing sector after power. CO2 emissions from aviation are expected to grow by over three-fold in the period to 2050, making it among the fastest growing sectors. After taking account of the additional global warming effects of aviation emissions aviation is expected to account for 5% of the total warming effect in 2050.

NASA and Boeing are conducting tests on a “blended wing” aircraft. This design allows for greater fuel efficiency since the whole craft produces lift, not just the wings. Engine Manufacturers are looking at alternative fuels,(hydrogen), electric engines, geared shrouded contra rotating fans, lean burn combustion and water injection technology as some of the methods of improving efficiency and reducing emissions.

Industry

Industry accounts for 14% of total direct emissions of GHG (of which 10% are CO2 emissions from combustion of fossil fuels in manufacturing and construction and 3% are CO2 and non-CO2 emissions from industrial processes such as production of cement and chemicals).

Direct emissions from both industry and buildings are both expected to increase by around two thirds between 2000 and 2050 under business as usual conditions.

Motor-driven systems consume about 65% of industrial electricity in the EU. In many applications, energy use can be cut by 87% just by adjusting the motor speed. Despite the scale of the potential savings, less than 10% of motors worldwide are combined with a variable speed drive. [Ref]

Pumps are the single largest user of electricity in industry in the European Union and energy savings of 3% would result in a 1.1TWH p.a. reduction in consumption or a saving of 0.54 Mton of production as outlined at the “IMechE Fluid Machinery Symposium” (2007). There are a number of research projects directed to advancing this target, [22], particularly to meet more stringent European pump selection criteria defined in “EU Directive 2005/32/EC “(2005).

Doubling the use of district heating from currently 6% to 12% in Europe would help reduce CO2 emissions by 9.3%.

Conclusions

Electricity is only one aspect of overall energy demand and the oil and gas which fuel transport and domestic/commercial heating will be exhausted at some stage – even with life extension of wells and new exploration and some point in the future – maybe 30 maybe 50 years – but finite nonetheless. If Scotland were to remain energy independent, then it would have to follow a route based vigorously on renewable energy and energy conservation. This might address such issues as the use of hydrogen as a vector for energy from variable output renewables, extensive use of biomass for domestic heating and road transport etc. More widespread application of existing energy-efficient technologies can significantly reduce the growth of GHGs. According to a recent McKinsey Global Institute report, the yearly growth in worldwide energy demand can be cut by more than two thirds by 2020 (to an annual rate of 0.6 percent from a forecast 2.2 percent) using current technology alone. The use of these commercially available energy-efficient technologies should of course be promoted with due regard to cost effectiveness.

Focus on R&D in the area of energy efficiency is essential, both in terms of short and mid- term improvements of existing technology, as well as breakthroughs on development and deployment of new energy-efficient technologies which can enable lower energy consumption without damage to economic growth;

In order to continue technological progress, we need an environment conducive to ongoing research, including adequate investment, as well as adequate collaboration at both EU and global levels. The Energy Star programme is an excellent example of such collaboration between the USA and the EU. [5]

IESIS calls on the Scottish government to:

- Provide learning support materials and indicators on energy efficiency to all energy providers and end users.
- Provide greater support to encourage and extend research and development and dissemination of advances in energy efficiency.
- Introduce financial measures to reward changes in behaviour on energy efficiency across society.
- Energy efficiency incentives and regulations in new and existing public buildings,
- Domestic and commercial business efficiency incentives through planning consents and Regulations to encourage implementation of local energy generation and recovery schemes
- Support of higher efficiency ITC research and development.
- Encourage switches in the mode of travel, and work practice.
- Provide tax incentives on vehicular use, and route extension to service providers.
- Increased spending in advanced efficiency research and development in transport systems.
- Increased spending in advanced efficiency research and development in power utlisation systems

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