Alternatives to New Nuclear Reactors in Scotland

This brief survey of the range of possible alternatives to nuclear power in Scotland was for the most part originally prepared for Nuclear Free Local Authorities (Scotland) and is reproduced, as adapted, with their permission but without liability for its contents.

1. Introduction

A wide range of energy and carbon emissions scenarios for the UK and Scotland suggest that with the right combination of energy efficiency measures, renewable energy, transport measures, and carbon capture from fossil-fuelled power stations, emissions reductions of over 80% by 2050 are feasible. The Tyndall Centre at Manchester University, for example, says nuclear power is not a prerequisite of the UK meeting its climate change objectives. (1)

Friends of the Earth Scotland, in its evidence to the Scottish Parliament's Economy, Energy and Tourism Committee's inquiry on "Determining and Delivering Scotland's Energy Future" says in all scenarios it has looked at, electricity provision is dominated by renewables, and there is a role for either fossil fuels with carbon capture, or nuclear power, **but none require both**. (2) And there is evidence to support the view that neither is strictly necessary in Scotland. (3)

If the government delivers on its EU commitments on renewables, and on its ambitious energy efficiency targets, the UK won't need to build major new power stations (coal, gas or nuclear) to keep the lights on, according to independent energy experts Poyry, up to at least 2020. The report also concludes that a strong drive for energy efficiency and renewable energy can reduce emissions and assist energy security. Friends of the Earth Scotland suggests a conservative approach, with a role for gas-fired combined heat and power (CHP) or perhaps a demonstration Carbon Capture and Storage (CCS) plant, but no need for conventional fossil or nuclear capacity.

2. Nuclear Investment makes Climate Change Worse.

Amory Lovins, Chairman and Chief Scientist at the Rocky Mountain Institute in Colorado, says new nuclear plants are so extraordinarily costly that they would save about two to 11 times less carbon dioxide (CO_2)emission per dollar, about 20 to 40 times more slowly than investing the same money in efficient use of electricity or in renewables and CHP. (5) He has previously said investments in energy efficiency typically save 7-10 times more CO_2 than nuclear power. (6)

In fact, Lovins argues, investing in nuclear power, is the worst thing we can do for climate change. It is vital to invest judiciously, not indiscriminately, in cutting carbon emissions. We must buy the fastest and most effective climate solutions. Nuclear power is just the opposite. The idea, put forward by some nuclear supporters that we need nuclear, renewables *and* energy efficiency - as if we had infinite money and no need to choose – does not stand up to scrutiny. We must choose the most cost effective buy first. In practice, keeping the nuclear option alive means diverting private and public investment from the cheaper market winners - CHP, renewables, and efficiency - to the costlier market loser. So every pound invested in nuclear will worsen climate change by buying less solution for every pound spent.

A portfolio of least-cost investments in efficient energy use and in decentralised generation will beat nuclear power in cost and speed and size by a large and rising margin. This isn't hypothetical; it's what today's market is proving decisively. Claims that more nuclear plants are needed to protect Earth's climate cannot withstand documented analysis or be reconciled with actual market choices. (7)

Electricity costs from new reactors planned in the US are estimated at 10 to 17 cents per kilowatt-hour. This compares with 8 to 12 cents for wind. And new large solar plants in California are expected to yield electricity prices about the same. Rapid new developments in solar and wind energy and energy storage technologies indicate that new reactors are likely to be economically obsolete even before the first new ones come online in the United States. (8)

3. Energy Efficiency

The top priority should be energy efficiency in buildings, and in particular, measures to improve existing buildings. This can address climate change and fuel poverty simultaneously. In Germany, which aims to deliver a 3% improvements in energy efficiency across the economy every year, there is a programme designed to systematically upgrade the entire building stock to "contemporary standards" over a 20 year period. It is funded through soft loans provided by a federal agency. Borrowers are able to take out low interest loans for measures that help older properties reach new-build standard through refurbishment. Only pre-1984 dwellings are eligible for loans: as in the UK, that was the date when building codes first mandated energy-saving standards. (9)

To date most of the policy initiatives on low and zero carbon housing have focused on new housing. It is important that building standards continue to raise rapidly the required efficiency standards of new buildings because otherwise increases in the overall building stock will increase carbon emissions. And building standards must be properly monitored and enforced. The low-carbon buildings strategy outlined by the Scottish Government's Sullivan report offers a good foundation. (10)

But existing houses lack the same degree of policy ambition despite the fact that 85% of homes standing today will still be lived in by 2050. Urgent investment and action is required to seize the cost effective energy savings which could be made in the domestic sector. A WWF Scotland report has examined how Scotland's existing homes can be transformed into low carbon homes and emissions from the domestic sector cut by 80%. (11)

A very broad range of physical measures needs to be employed in any retrofit strategy in order to make the required substantial improvements in the energy performance of existing housing. This will include much wider use of solid wall, external insulation for example. But the analysis for WWF shows that physical measures will need to be combined with consumer behaviour change, improved standards of domestic appliances, and there will need to be a significant introduction of low and zero carbon technologies including microgeneration.

The WWF report also suggests making use of the Energy Performance Certificates system to further incentivise energy efficiency, by progressively raising the standard required for any house to be sold or let.

4. Fuel Poverty

Energy Action Scotland estimates there are currently more than 700,000 households, one in three, in fuel poverty in Scotland. The recent significant increase in fuel poverty is due to the dramatic increases in domestic energy prices. The Scottish Government is required by the Housing (Scotland) Act 2001 to end fuel poverty, as far as is practicable, by 2016. Along with its climate strategy, the Scottish Government will have to develop policies which can provide affordable warmth to those suffering from fuel poverty by 2016. Clearly new reactors can have no role in that. If the Scottish Government's target on the eradication of fuel poverty is to be met it will have to give the highest possible priority to increased investment in energy efficiency.

There will need to be significant new investment in Scottish housing. Energy Action Scotland accepts that Government cannot provide all of this funding and suggest that a range of measures such as interest free loans, equity release schemes and green mortgages will need to be introduced. It has been estimated that around £150 to £200 million per annum needs to be spent if Scotland is to meet the 80% target. (12)

Fuel poverty is particular serious in rural areas of Scotland off the gas grid, particularly for those reliant on oil-fired central heating. A recent pilot study ran from April 2006 to June 2008 and involved 87 households who received a new renewables-based central heating system. These were mostly heat pump systems (either air-source or ground-source), with a small number of biomass boilers/stoves and solar thermal systems also installed. Air source heat pumps were found to provide the greatest value for money in terms of the number of people lifted out of fuel poverty. (13)

5. Renewable Targets & Heat.

The Scottish Government has set ambitious new targets to generate 50% of Scotland's electricity from renewables by 2020, and 31% by 2011. (14) But it is also important to remember that around 80% of energy used in Scottish homes is in the form of heat. New solutions will be needed to reduce carbon emissions from heat generation.

The Forum for Renewable Energy Development, Scotland (FREDS) report on renewable heat offers practical steps and useful ways forward. These included reviewing options for existing buildings to maximise the uptake of renewable heat and reduce demand. (15)

In contrast nuclear power only provides electricity. It contributed around 20% of the UK's electricity supply in 2005. Carbon dioxide emissions from the energy sector also result from the use of fossil fuels for heating, and transport. When these other sectors are taken into account nuclear power, in fact, supplies less than 4% of total UK energy used. Consequently, replacing nuclear reactors with gas and coal power stations by 2020 would raise carbon emissions by only about 4%-8%. Kevin Anderson, senior research fellow at the Tyndall Centre for Climate Change research points out that we could very easily compensate for that with moderate increases in energy efficiency. (16)

6. Low and Zero Carbon Technology

As well as a massive insulation programme, carbon emissions from existing houses will only be reduced by the required 80% if low and zero carbon technology (LZCT) is also installed. This might include the installation of microgeneration schemes, such as solar panels and micro-CHP boilers, or connection to CHP - district heating schemes. Scotland has roughly 2.5 million dwellings, so to install some form of LZCT in every house over the next 42 years, we should be installing 60,000 every year. Brenda Boardman at Oxford University's Environmental Change Unit estimates that the new Carbon Emissions Reduction Target (CERT) scheme will result in a paltry 121,000 installations over the next three years over the whole UK. Assuming Scotland's receives its fair share of the money, this would mean about 4,000 installations every year for three years. (17)

7. Micro-CHP

Micro CHP is an innovative new technology, which has significant potential to reduce carbon emissions. There are several competing technologies, but all would replace a conventional domestic central heating boiler, and produce electricity as well as how water for heating.

Whilst new reactors are not expected to produce any power until around 2020 at the earliest, micro CHP can be installed 1kW at a time, producing power from day one. The Baxi Group

expects to introduce a micro-CHP boiler onto the UK market in 2009. (18) In terms of capacity, if all domestic gas boilers are replaced (as they reach the end of their useful life) with micro CHP, the UK could in theory install 1.5 million micro CHP units every year. That is equivalent to 1.5GWe, or not far off the size of one nuclear power station in 2010, another in 2011 etc. By 2020, we could have the equivalent of ten new reactors powered by micro CHP. And if it didn't work out for some reason, we could just stop installing them; on the other hand, with nuclear you have to commit to the whole £2billion (or more) price tag for a single station and if, after 10 years construction, it doesn't stack up, you have absolutely nothing to show for your money. (19)

8. Combined Heat and Power (CHP)

Our current centralised system of electricity generation is highly inefficient with two thirds of the energy generated wasted before it even reaches the consumer. It relies on a small number of huge power stations which generate electricity miles away from the point of consumption, and which throw away two thirds of the energy in the form of hot water. This is hugely inefficient. A more decentralised system could use proven technologies, such CHP, to produce energy far more efficiently by capturing the heat usually lost in electricity generation, and piping it to nearby houses via a district heating scheme. CHP schemes can achieve an efficiency of around 85% for the combined production of electricity and heat.

Aberdeen already has three schemes run by Aberdeen Heat and Power Co Ltd - an independent, not-for-profit company established to develop and manage the CHP schemes: The Stockethill project supplies heat and hot water to 288 flats in 4 high rise blocks of flats; The Hazlehead project supplies 4 high rise blocks of flats, a Sheltered housing scheme, school and swimming pool; and the Seaton project supplies 503 flats in 6 high rise blocks. (20)

Boiler House and one of the 4 blocks in Stockethill served by the scheme.

Clydebank Housing Association also has a CHP scheme which serves 7 multi-storey blocks with almost 400 flats, and 1,000 homes altogether along with a primary school and community hall. 70% of the high rise tenants are over 60. The flats originally had expensive and ageing electric storage heating. The cost to tenants is now around £6.50 per week. (21)

Edinburgh University has three CHP schemes, at George Square, Kings Buildings and Pollock Halls. (22) As part of the plans for the regeneration of the Craigmillar area, a feasibility study is being carried out into the use of CHP. If practical, the new town centre developments would be the first to benefit from the scheme. (23) And the Edinburgh Community Energy Co-operative has jointly commissioned a feasibility study with Waterfront Edinburgh Limited (the City Council company promoting the regeneration of the North Edinburgh waterfront area), to look at the suitability of various renewable energy and CHP technologies for both the new developments at Granton Waterfront, and the existing communities in the area. (24)

WWF suggests accelerating the introduction of CHP/District Heating to Scotland's existing homes through a package of support measures for local authorities. Scotland has a high proportion of dwellings where CHP/District Heating could be used. This is best integrated with heat requirements from non-domestic buildings.

In 2006 there were 87 good quality CHP schemes in Scotland generating over 3 GWh of electricity and 8 GWh of heat. This represents 6% of power generated and 8% of heat use in Scotland. These CHP schemes mainly serve large process sites in the petrochemicals, chemicals and food sectors, with some smaller installations in the public and service sectors, hospitals, swimming pools, hotels etc. A report by AEA Technology for the Scottish Government calls for the mapping of opportunities for District Heating and CHP, to assess the additional potential for carbon emission reductions. (25)

9. Powering Edinburgh

A study by PB Power, commissioned by the City of Edinburgh Council, WWF Scotland and Greenpeace, entitled Powering Edinburgh, gives a blueprint for how cities can introduce decentralised energy and generate power close to where it's used. The report shows how this heat could be used to heat Edinburgh's buildings. Edinburgh is ideally positioned to generate electricity closer to the city and capture the heat and using it to warm homes and offices. By decentralising its energy generation, the report says, Scotland can turn its back on nuclear and burn less fossil fuels, with huge benefits for the environment. Reliance on imported gas would also be cut.

Powering Edinburgh concludes that only decentralised energy can put Edinburgh on a pathway to meet the government's 2050 CO_2 reduction targets. A nuclear route would fall well short of the 60% cut required and produce radioactive waste that remains deadly for tens of thousands of years. (26)

CHP Boiler House at Edinburgh's Western General Hospital

A report by Pöyry Energy Consulting shows that industries across the UK could generate as much electricity as 10 nuclear power stations and halve gas imports by installing or extending CHP plants. Poyry found nine sites where CHP could be applied or extended. Two of these sites are in Scotland, one at Grangemouth and one near Peterhead. Currently 5.5GW of electricity is produced by CHP plants, but Poyry suggests there could be up to 16GW more. (27)

London First – the Capital's Employers' Group – has called for a quarter of London's energy supply to be decentralized to reduce CO_2 emissions from London's buildings by 10% by 2025. The report, Cutting the Capital's Carbon Footprint - Delivering Decentralised Energy, calls for collaboration between central Government, the Mayor and his agencies, energy companies, developers and boroughs to decentralise a quarter of London's energy. Linking large heat

users such as housing estates, leisure centres and hospitals to locally-placed electricity plants can deliver massive efficiency gains, instead of centralised generation with its huge waste heat losses and losses from many miles of high voltage cables. (28)

10. Microgeneration

Research suggests the widespread installation of micro-generation could provide as much as 30-40% of Scotland's electricity needs by 2050, making a substantial contribution to carbon targets. (29) A House of Lords European Union Committee report recently stressed that renewable heat technologies and micro-electricity generation should be as important a part of meeting the UK's renewables target as large-scale electricity generation. (30)

EU member states have agreed to a binding target of producing 20% of the EU's energy (not just electricity) consumption from renewable sources by 2020. The European Commission has proposed the UK's contribution to this should be to increase the share of renewables in our energy mix to 15% by 2020. The UK Government published proposals to enable it to meet this target on 26th June 2008. The proposals suggest the UK will need the installation of: 100,000 heat pumps, 7 million solar hot water systems and biomass heating sufficient to provide the needs of 3.2 million households. (31) The Renewables Advisory Board suggested the following installations would be necessary in existing residential buildings across the UK by 2020. As a rough guide we might expect Scotland to install 10% of these systems:-

Photovoltaic solar panels 680,000
Solar Hot Water 1,300,000
Micro-wind turbines 1,170,000
Air Source Heat Pump 1,440,000
Ground Source Heat Pump 950,000 (32)

The expert panel chaired by Lynne Sullivan, which made recommendations on a Low Carbon Building Standards Strategy for Scotland in December 2007 is likely to lead, if the recommendations are accepted, to substantial improvements in Building Standards in 2010, 2013 and 2016, such that new buildings will be net zero carbon for space and water heating; lighting and ventilation by 2016/17. This will give a considerable boost to the micro-generation industry. (33)

In the meantime, The Scottish Planning Policy Guidance No.6, published in March 2007, included an "expectation" that all future proposed developments above 500m^2 should incorporate on-site zero and low carbon equipment contributing at least an extra 15% reduction in CO_2 emissions beyond the 2007 building regulations. (34) Fiscal incentives will be required to encourage owners of existing buildings to install micro-generation technology, but by using the Building Regulations and the Planning Regulations to increase the number of installations, the price should start to come down as microgeneration equipment begins to be manufactured in greater numbers.

Policies to drive microgeneration are particularly appropriate to Scotland, with significant numbers of dwellings not connected to the gas grid. The high cost of oil-fired central heating will make microgeneration, especially for heat, more competitive sooner.

11. Anaerobic Digestion

Given that waste disposal, particularly biodegradable waste disposal, is a key producer of methane which is a greenhouse gas 21 times more harmful than CO_2, and the EU landfill directive and other environmental legislation is forcing changes in the treatment of waste, Anaerobic Digestion (AD) is going to be an increasingly important technology in Scotland. AD plants will use energy from biodegradable sources – such as food and farm waste, treat it

and produce heat and electricity for the localities around the plant and for integration onto the national grid. Indeed, other European countries are leading the way with AD- the resultant fuel, biogas, is used in Sweden as a vehicle fuel and injected into the national gas grid in Germany. (35) (36)

Anaerobic Digestion is currently an expensive way of dealing with food waste, according to WRAP – the waste and resources action programme – but as more digestion plants come into operation it will become far cheaper. (37)

12. Renewables

The Scottish Executive commissioned a study in 2001 (38) that considered Scotland's potential renewable capacity. Taking into account various constraints, such as environmentally sensitive areas, onshore wind energy alone could provide around 45TWh, which is equivalent to Scotland's entire projected electricity consumption in 2020.

The Marine Technology resource is very large. Offshore wind has the potential to produce around 82TWh; wave power 45.7TWh and tidal energy 33.5TWh.

The Crown Estate announced in November 2008 that it was inviting initial proposals from developers for the UK's first commercial marine power sites, located in the Pentland Firth and surrounding waters. The Round 1 leasing programme is aimed at delivering 700 MW of new offshore wave and tidal power by 2020 and is expected to bring significant economic benefits to north Scotland. Unlike some other forms of renewable energy, the energy supply from tidal machines is predictable. The opening up of the Pentland Firth and surrounding waters – which contains six of the top ten sites in the UK for tidal power development – is central to meeting Scottish government green energy targets. (39)

The UK has the potential to generate up to 30% of its electricity needs from marine power and become a world leader in the technology if it continues its rate of innovation, according to a report from industry analysts Frost and Sullivan. While there remain a number of significant obstacles to widespread adoption of the technology, marine energy is the most reliable source of renewable energy and the UK is one of the best areas in the world for harnessing its power. If wave and tidal systems continue to be developed at their current rates, approximately 3GW could be installed in Europe by 2020 – much of it by UK companies. (40)

Other resources which offer relatively small, but potentially cost effective supplies include: small hydro (1TWh); energy crops (1TWh); Agricultural Wastes (3.5TWh); Forestry residues (3.1TWh) and Landfill gas (0.6TWh).

13. Hydro Power

Britain's old water mills, for example, some of which date back to the 11th century, could become a major force in the fight against climate change if refurbished with new turbines installed. UK Government figures suggest that if the resource is fully tapped, small-scale hydropower could provide up to 10TWh per year - 3% of the UK's electricity needs. With more than 20,000 mill sites across the UK, the potential is huge. There are groups across the UK, with several dozen refurbishments projects in various stages of planning or construction. (41)

A recent study on Scotland's hydro power potential indicated that there are 1,019 potential schemes, including run-of-river schemes and new storage schemes with a total practical potential of 657 MW that could deliver 2.77 TWh of electricity annually. (42)

14. Farm Energy

In June 2008, Scottish Renewables launched a drive to urge farmers and landowners to 'get into renewables'. The green energy trade body has estimated that Scottish farms have the potential to generate electricity equivalent to one sixth of Scottish household's total demand by each farm installing just one small 15kW wind turbine – about 2 TWh. (43)

15. Intermittancy

One of the loudest arguments of those who support new reactors is that even if renewable energy markets grow large, renewables cannot meet baseload demand so Scotland will still need some conventional generation.

Late last year, a German economics ministry experiment showed that distributed power can indeed produce reliable baseload in a secure and reliable manner. Thirty-six decentralised renewable plants - a mix of biogas, wind, solar (photovoltaics, or PV) and hydropower - were linked by three companies and a university in a nationwide network controlled by a central computer. The joint project is capable of supplying electricity around the clock regardless of weather conditions and electricity demand. It takes advantage of the unequally distributed energy potential across Germany and of a permanently stored source of solar energy, biomass. (44)

During the day of the press conference to announce the results of the experiment, there was no wind at all in Germany and the country was covered by cloud. This intermittency of solar and wind meant that the biomass plants played an important role on that day. (45)

16. Conventional Generation

The majority of thermal plant capacity in Scotland will reach the end of its planned life in the next 10 to 15 years. Scotland has five major power stations with a combined installed capacity of the 7,046MW. Of this, 4,276MW will either require closure or major investment to ensure life extension by 2020. This includes Cockenzie (to close by 2016), Longannet (investment required by 2020) and Hunterston (to close by 2016). Torness is currently expected to close in 2023, although its life may be extended, and much of Peterhead's capacity will be out of commission by 2030/31.

Scottish Power says it is presently undertaking a feasibility study into investment options for Longannet and Cockenzie. Consideration is being given to installing Advanced Supercritical Coal technology plant replacement; upgrades to existing plant with new pollution abatement equipment; and, new build Combined Cycle Gas Turbine (CCGT) plant. This review is expected to be completed by early 2009. An application for new planning consents will follow soon thereafter. It says all future coal scenarios include the retrofit option for carbon capture and storage.

Scotland's Energy Minister, Jim Mather, says new fossil fuel power stations should be ready for carbon capture technology. The Scottish Government is consulting on draft guidance for applications to build thermal power plants in Scotland. The Guidance would require new power stations over 300 Megawatts to be able to incorporate carbon capture technology in the future. He says: "Carbon capture and storage has the potential to cut emissions from fossil fuels by 90 per cent. Any investment designed to last 30 years or more will need to be compatible with our climate change targets". (46)

Unfortunately, simply requiring a new coal-fired station to be 'capture ready' gives no guarantees that carbon capture and storage will ever be implemented. Indeed given the economic uncertainties surrounding 'capture ready' technologies, it seems likely that any such plant would continue to operate unabated for many years, severely compromising Scotland's climate targets.

The World Development Movement (WDM) and Friends of the Earth Scotland (FoES) described the Scottish Government's consultation as a "missed opportunity" which "risked jeopardizing its ambitious climate change targets" if it allows polluting coal fired power plants to be built and operated in Scotland. The groups want to see the guidance incorporate a greenhouse gas emissions standard so that any new coal-fired power stations built would have to be fitted with carbon capture and storage technology from the outset. (47)

Logannet and Cockenzie released an estimated 3.1MtC (million tonnes of carbon) in 2005. (48) New supercritical boilers would save about 20%, so this would come down to around 2.5MtC (but might end up much worse to begin with if Scottish Power ran these stations at a higher load factor). Scottish Greenhouse Gas Emissions in 2003 were around 17.6MtC. (49) Reducing this by 80% would give an allowable limit in 2050 of only around 3.5MtC. So, if Longannet and Cockenzie are still operating without CCS in 2050, they would be emitting over 70% of the carbon equivalent allowed, and Scotland would be left with almost no allowance for anything else such as transport or gas boilers. (50)

CCS technology has yet to be demonstrated on a large scale power plant anywhere in the world. As a result, new coal plants are currently only proposed to be 'capture ready' at the stage of construction, with the intention of retrofitting CCS at a later date, once its financial and technical feasibility has been established. WWF points out that there is no deadline for new coal plant to be fitted with full scale CCS, or any guarantee that this will ever be done. "Reliance on an as yet unproven technology, however promising it may be, is a risky business - the future of the planet's climate cannot rely upon good intentions." (51)

However, one way to drive innovation would be to require all new conventional fossil-fuelled plant to meet a 'greenhouse gas (GHG) standard', as applied in California, to ensure emissions decline in line with climate targets. In practice a tough target (say 300 or 350g/kWh) would both favour renewable generation, and drive any fossil plant to one of two choices: combined heat and power (CHP), or carbon capture and storage. Carbon capture technologies will be significant globally, and Scotland may be well positioned to commercialise them. A swift move to operationalise CCS in Scotland would show global leadership.

Pete Roche, December 2008.

Annexe – Other Scenarios

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