ELECTRIC POWER IN THE NEW SCOTLAND

An Address to the Scottish Government, the Scottish National Party and anyone else who wishes the country a prosperous future and a respected place amongst the community of nations

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1 Introduction

The SNP's *Manifesto 2007* says "We will consult on the means of reducing Scotland's emissions of greenhouse gases." This contribution to the consultation is aimed at the Party's leadership and other policy-making and advisory bodies. It is also aimed at the general membership because these views are not widely held within the Party. They are, however, widely held within the industry and by others who have studied the subject in depth. This is probably because the issues surrounding nuclear power, renewable energy and energy saving have never been discussed widely and in depth within the Party. We therefore need to examine the character of each of the available options in some depth. Those who have to make the investments in either the public or the private sector will make the ultimate choices. I have not burdened this short pamphlet with references and original data but I believe the facts are verifiable and indeed generally accepted. My aim is to marshal them in a way that may be new to many readers and draw logical conclusions.

2 The Argument

Clear your mind of cant.
Dr Samuel Johnson

The use of fossil fuels – coal, oil and natural gas – has brought great benefit to mankind but at the present rate of burning it will eventually have catastrophic effects on the world's climate. International action to deal with the threat has a long way to go but Europe at least has accepted realisable targets and Scotland has to be fully involved. This country is unusually well endowed with fossil and non-fossil sources of energy though some of them are rapidly depleting or approaching the end of life. The problem is to deploy them to the best advantage, taking into account such factors as security of supply and cost. These have to be reconciled with climate-change targets if Scotland is to be economically and socially successful. The test of policy is how well it measures up to those needs. The starting point has to be recognition of where and in what proportions the demand for energy arises.

The key facts are that transport, heating of buildings and heat for industrial processes together account for four fifths of our total energy consumption and electricity generation for only one fifth. Despite this, the policy and campaigning of the SNP (and every other party!) has focused on electricity and specifically renewables versus nuclear as the dominant energy issue. Debate about the political and other measures needed to deal with the much bigger heating and transport

demands has been absent, even though these demands are based almost entirely on gas and oil, both greenhouse gas producers.

It is a very welcome development that the SNP's *Manifesto 2007* recognises the need for heat conservation and for non-fossil fuels for vehicles. Unfortunately, the Manifesto's praiseworthy aims are distorted by the old confusion of energy with electricity and by dogmatic attitudes to the various technologies available. The Manifesto accepts the need for expert involvement in, for example, the toughening of building regulations but has seen no need for expert involvement in its consideration of electricity generation.

This paper concentrates on these deficiencies because they threaten the success of the whole energy policy and the economic policy that goes with it. We urgently need an objective assessment of all the options available, excluding none.

3 Electricity Generation and the Rest

William Ewart Gladstone: *Of what use is your Electricity?*
Michael Faraday: *Sir, one day you may tax it.*

Electricity generation is essential to our whole way of life. Still, the amount of attention it gets in political circles and in the media is wildly disproportionate, considering it is much the smallest of the three main energy sectors and the easiest prospect for minimising carbon dioxide emissions. The quotations from *Manifesto 2007* below show the baleful influence this has had and is still having on the campaign to reduce greenhouse gases overall. Power stations and transmission lines may be conspicuous but in total they contribute far less to global warming than the millions of chimneys and vehicle exhausts.

Something must lie behind this failure of a sense of proportion. I suggest it stems in part from the "environmentalists" (and politicians picking up their ideas) finding this conspicuous target more appealing than mundane matters like house chimneys, family cars and flights to the sun. A more powerful factor in the case of nuclear power (and hence its supposed opposite, renewables) has been the alleged association with nuclear weapons. The fact is that states that have nuclear weapons got them first. Most went on to a civil nuclear power programme, not the other way round. A dozen other countries around the world, from Canada to Japan, have power stations but no nuclear weapons. The misconception has, from the beginning, created an atmosphere of suspicion and goes on building on it. In this atmosphere it is difficult for citizens to form sensible views on the evidence. But let's try!

4 Nuclear Power

In the bowels of Christ I beseech you, think it possible you may be mistaken.
Oliver Cromwell

The SNP's highly successful *Manifesto 2007* is marred by the inclusion of two self-contradictory and dangerous paragraphs. Under the heading "A Greener Scotland" it says "In government we will introduce a Climate Change Bill with mandatory carbon reduction targets ... As a starting point a Scotland led by the SNP will say no to new nuclear power stations..." Translation: "We will reduce carbon emissions and get rid of the biggest producer of carbon-free energy we have." How illogical can you get? Curiously, while saying "No to Nuclear", the manifesto gives no reason. All it says is "...Scotland doesn't require a new nuclear power station." In that absolute sense, of course, Scotland doesn't require renewables or coal or gas or oil. There is always something else. Why discriminate against nuclear? We have already seen that the connection with nuclear weapons is misconceived. Equally groundless is the story that Scotland was "picked-on" as a "remote" location for dangerous works and a string of similar stories. If we recognise how mistaken those foundations of our anti-nuclear stance are, it must be possible to get rid of the unspoken assumption that nuclear power is uniquely unacceptable. Having got that far we must in fairness see if there is anything in the current "Dangerous, dirty, expensive" charge.

DANGEROUS? The industry's health and safety record for its employees and the public is one of the best. If the activists were really concerned with safety they would be campaigning where the record is truly dreadful as in road transport and even hospitals, each of which accidentally kills around 5,000 people every year in the UK, while nuclear power kills none. Traffic accidents and MRSA have familiar and tangible causes. Radioactivity is not immediately detectable by human senses. Its military use was shocking and set the stage for civil uses to be tarred with the same brush. The various pressure groups accepted its medical use but nuclear power was a ready made bogeyman. We have had nuclear power stations in Great Britain for forty years. In that time every incident, however trivial, has been blown up into a scare story and the atmosphere of dread perpetuated. Yet there has not been a single nuclear emergency and the industry has an enviable record compared with coal, oil and gas.

The excellent safety record of nuclear power is no accident. The industry effectively isolates the dangerous radioactive material from the living environment. That is why nuclear power contributes only 0.5 % or so to the annual dose to the population. 85% of this dose is from natural sources (including 11.5% from what we eat and drink!) and 14% is from medical treatments.

Chernobyl? Yes, the exception that proves the rule. Yes, it was grossly mal-operated but the effects would not have been catastrophic if the reactors had been designed to comply with the international rules; these rules (adhered to by every other country) prohibit designs with the capability for a runaway reactivity such as led to the Chernobyl explosion. Even so, keeping a sense of proportion, the year-after-year deaths detailed above can be compared with the World Health Organisation's forecast that “eventually around 4,000 deaths may be attributed to Chernobyl.”

DIRTY? Nuclear power certainly produces waste material as does every other human activity. The issue is not whether it exists but what is to be done with it. Will it be dumped on the ground like mine spoil? (Remember coal bings? Remember Aberfan?)

Will it be discharged into the air as from all sorts of chimneys and vehicle exhausts? (Think of acid rain, smog and global warming.) Or will it, like radioactive waste from power stations, be carefully packaged in a way that confines the radioactivity? Waste certainly, but “dirty” is an abuse of language. Headlines like “there is of course no solution to nuclear waste” used to abound in the Scots Independent and elsewhere. They have mercifully died down since the Committee on Radioactive Waste Management (CORWM) reported its conclusions in favour of long term storage deep underground with secure containment above ground while the ultimate store is being built. This solution has been accepted by the UK Government and it is to be hoped that the SNP-led Scottish Government will do likewise for CORWM was better equipped to reach technically and socially sound conclusions than any political party. And let's not forget that nuclear power has the same minimal carbon dioxide footprint as the renewables. In short, nuclear power is clean.

EXPENSIVE? More expensive than what? The days of dirt-cheap coal and oil are gone. Nuclear does look expensive until you compare it with the alternatives. We will do that later. At this point we shall look at the main elements of cost and especially those that figure in public controversy. The capital cost of the station accounts for most of the cost of its electricity output. Uranium accounts for only about 5% so even if it inflated in the years to come the effect on electricity prices would be small. Capital cost has now fallen since the early days of the industry due to technical development. The latest designs from European and American manufacturers represent a further leap forward. They are greatly simplified without sacrificing any safety standards. They are designed for easier and quicker construction and dismantling. They are designed to use the uranium fuel more effectively and produce less waste. These designs have been adopted for the new nuclear stations

in France, Finland, South Korea and China. If all the existing nuclear power stations in Britain were replaced by new ones of the same total capacity, they would add less than 10% to the existing waste over their lifetime, so replacing nuclear stations would make little difference to the existing disposal task. Costs of decommissioning and waste disposal are not great (a few percent of production cost) if set aside throughout the working life of the station. That is now mandatory and is the basis on which future nuclear costs are calculated. It is no longer possible to neglect this provision and leave an expensive legacy for the next generation.

5 Renewables

Down dropt the breeze, the sails dropt down…
Day after day, day after day,
We stuck nor breath nor motion.
Samuel Taylor Coleridge*, Rime of the Ancient Mariner*

Renewable energy has the virtue of its name – it will never run out. It also has the virtue of producing minimal carbon dioxide. It produces some CO_2 in the construction operation and final demolition of the wind-farms, wave machines etc. but it only amounts to 2 or 3% of what the same capacity of fossil-fuelled plant would produce over its lifetime (the figures for nuclear power are very similar). On the other hand, renewable energy is entirely dependent on the character of the natural forces it taps into. Hydro-electric power differs from the other renewables we are discussing, being reliable and controllable, but it is already pretty well fully exploited in Scotland. Wind and wave energy is expensive because the machinery to harness it is, in aggregate, much larger than the compact thermal plants, whether fossil fuelled or nuclear. It would take 2,500 wind turbines or 6,000 wave machines to equal the energy output of Longannet power station.

Secondly, wind and waves are variable and intermittent. A typical wind installation produces on average between 20 and 30% of its rated power. Wave motion is smoothed out to some degree but still achieves no better than 50%. The maximum rated power determines the size of the plant and hence its capital cost but its income is determined by its average power output. Think about it. Moreover, wind speeds below 15 mph and above 45 mph are not useable. Windless days and storms are by no means unknown. This degree of uncertainty can be accommodated within normal grid operating margins as long as the capacity of the renewables amounts to 10 to 15% of system capacity. Beyond that, it needs predictable back-up in the form of fossil fuelled plant. It is no consolation that it may

be windy in the east when it is calm in the west unless the east has been provided (at considerable cost) with enough excess capacity to replace what is missing in the west. In short, an ambitious renewables programme is not only expensive in itself but it demands an expensive parallel investment in thermal plant. It is not surprising then that the current surge of investment in wind energy can only be sustained by subsidies, at present in the form of the Renewables Obligation. At risk of over-simplification, this scheme essentially obliges every electricity supplier to take a certain proportion of its supplies from renewable sources, regardless of cost. Two thirds of the cost of the electricity produced under this scheme is a subsidy ultimately paid for by the consumer. The Government is committed to keeping up this level of support until 2027. The effect of these extra costs on Scotland's chances of economic success must be damaging.

Tidal energy is another but more distant prospect. It is time to stop being beguiled by meaningless comparisons of the Pentland Firth with Saudi Arabia. Tides are predictable but the velocity of the stream varies twice daily from its maximum at full ebb and flow to zero at slack water. The power output of a turbine, whether wind or water-driven, varies as the cube of the flow velocity. The effect is that the output of a tidal flow turbine averages one eighth of its maximum power. For this and for other engineering reasons it is inherently expensive. Ambitious ideas for massive exports to the continent need to be tempered by comparison with the much cheaper competition e.g. Norwegian or Russian gas. There may, in fact, be better uses for it in, for example, electrolytic production of hydrogen at an adjacent site as a fuel for carbon-free vehicles.

A sore point for almost all the renewables promoters is the cost of transmission from remote locations to the main centres of population. Building and operating new transmission lines over long distances will obviously cost money which should be part and parcel of the new generators' cost. Whether a specific charge is fair and reasonable can be challenged but the principle is fair. The cries of indignation over the costs are really a plea for a further subsidy. Fair enough if it is agreed that renewables are to be promoted at any price but there should be no pretence about it.

This discussion of renewables is confined to the very large resources. There are other renewables or CO_2-neutral resources such as forestry thinnings and landfill gases but they are small and cannot affect long-term planning and major policy decisions. They do however provide a resource for relatively small and basically heat-producing community-based schemes in rural areas. These may not be economically viable but subsidies may well be justified here on grounds of social policy.

6 Micro-Generation

Herbert Spencer's idea of a tragedy is a beautiful theory slain by a brutal fact.
T H Huxley

Micro-generation has to be got into perspective before it does irreparable harm to the cause of energy saving and gets renewables a bad name. Micro-generation is promoted without a word of explanation as to why, for the first time in industrial history, the economies of scale don't apply. From Edison's time onwards, central power stations have succeeded precisely because their product is so much cheaper than that of individual generators.

Under "Energy Saving," *Manifesto 2007* promises to "... encourage more local energy production." and "... will consult on proposals to introduce a planning presumption requiring new buildings in Scotland to include sufficient renewable generation on-site to deliver between 20% and 50% of energy needs." Generation on-site would not save energy – it would only substitute a lot of small local producers for a few big central ones. The claim is that mounting a million roof-top (or gable-end if you prefer it) wind-driven generators will reduce carbon dioxide emissions. The bulk of the energy wasted from buildings is not electricity but just plain gas-fired heat. The location of these wind-driven generators amongst an array of buildings ensures that they will not perform as claimed but even if they did they would simply be replacing a minor part of the demand on the public supply. Half of our public electricity supply comes from nuclear and hydro-electric stations and is already substantially free of CO_2. The fossil fuelled part should be cleaned up progressively.

Having spent some £2 billion and disfigured a million skylines what would we have achieved? Nothing, except to rob the taxpayer of a few hundred millions in capital grants.

Technologies do exist for making cost-effective energy savings. It is important not to bury them under a lot of spurious and wasteful diversions. Scope exists for genuine savings by not-so-micro combined heat and power schemes. There are enormous and cost-effective heat savings to be made in houses and other buildings. Heat conservation in existing buildings must not be neglected. Without it, we cannot reduce total energy consumption; we can only slow down the increase due to new building.

It is essential to prevent the drive for micro-generation from diverting attention and funding from these major tasks and opportunities.

7 Fossil Fuels

To Noroway, to Noroway,
To Noroway o'er the foam.
Anon., *The Ballad of Sir Patrick Spens*

Great Britain is now a net importer of fuel and even an independent Scotland will not be able to isolate itself from the underlying trend. Deep-mined coal is closed down (rightly or not) and opencast coal production falls far short of demand. Oil and gas are fed into the world market and having passed their peak will be progressively replaced by middle-east oil and Norwegian and Russian gas. There is no specific threat to the security of supplies but there is a general presumption that a high proportion of indigenous sources is a desirable safeguard against the unpredictable.

Renewables are not necessarily available when required. Nuclear reactors cannot cope with frequent and rapid load variations.

Of all the sources of electricity fossil fuels are the least dispensable. No other can provide, on a massive scale, the reliability and flexibility to meet consumers' daily and seasonally varying demands. (On a typical day the peak demand is three times the lowest off-peak.)

Fossil fuels also provide the cheapest electricity as long as they are allowed to discharge their waste products into the atmosphere. Sadly, fossil fuels are basically carbon and the product of burning is the green house gas carbon dioxide. We are on the horns of a dilemma.

There are three possible responses:

- to reduce demand;
- to substitute gas for coal, thus reducing CO_2 production;
- to capture the CO_2 before it enters the atmosphere and store it somewhere.

As ever, the best solution to the dilemma is likely to be a combination that covers a range of circumstances. For instance, the best means of coping with a major but infrequent loss of wind-power might well be a back-up installation of simple open-cycle gas turbines. This would be the cheapest possible device. It would run so infrequently that its CO_2 output could be tolerable.

The solution of reducing demand is unrealistic. Millions are rightly doing what they can but much more is needed. We are not looking for a marginal reduction of greenhouse gases but something in the region of 50–80%. Demand has been rising

by about 1% per annum in Europe and North America and even more in the developing world. The rising number and buying power of the population and the introduction of new gadgets overwhelm the continuing improvement in the efficiency of electrical appliances. Moreover, any major attack on the oil greedy road transport sector must involve electricity for electrical and hybrid vehicles and public transport. Both the base load and the variable demand are bound to increase.

The second solution, substituting gas for coal, would certainly reduce CO_2 output. Natural gas is methane, CH_4, i.e. not wholly carbon. Natural gas also enjoys a great advantage being free of ash, sulphur and other contaminants. This allows it to be burnt in internal combustion turbines with a substantial improvement in thermal efficiency over the coal-burning alternative. The combined effect is to reduce CO_2 output by about 40% compared with coal. So far so good but 60% remains and there is a constant anxiety about the security and price of gas supplies in a rather unstable world.

The third solution, CO_2 capture and storage, is the most far reaching if it can be developed on a commercial scale. This solution is applicable to both coal and gas. It is applicable only to large static fuel users such as power stations but not to dispersed and mobile users such as road and air transport. It requires the carbon dioxide to be separated from the three-quarters of the flue-gas that is nitrogen. Chemical and physical methods are known in principle but still need development. There is worldwide interest in the development of equipment to move from theoretical possibility to practical reality. The ultimate world market is immense but the cost of development is well beyond the capability of one small country. Scotland has much to offer technologically but it can only realise its potential in association with others.

Manifesto 2007 wisely proposes campaigning to have the UK and EU facilities and programmes located in Scotland. At this stage figures are speculative but educated guesses by several institutions suggest that with the extra capital cost and the cost of pumping the CO_2 into underground caverns, the cost of electricity would be pushed up by around 50%, putting fossil fuels into the same high-cost bracket as renewables. Fossil fuels will thus become greener but simultaneously uncompetitive for base-load generation where there is an alternative. For the variable demand there is no alternative so the extra cost will have to be borne.

8 Counting the Cost

My fortunes are not all to one bottom trusted.
William Shakespeare, *The Merchant of Venice*

The high minded view that “cost doesn't matter” and the innocent view “it costs practically nothing once the initial cost is paid off” tend to evaporate when the bills come in. Unfortunately the consumer doesn't always see the true cost. All too often it is masked by subsidies that only appear on a different bill. Subsidies are not necessarily wrong but they should always be visible at the point of decision-taking so that their impact on the cost of living and on the whole economy can be seen. This is at the core of the problem of weighing up the various options for electricity generation.

We have seen that in principle fossil fuels, renewables and nuclear power can all make a contribution to meeting the CO_2 reduction targets and the diversity that is necessary for security of supplies.

Nuclear and renewables are both essentially indigenous but neither is capable of meeting all the varying demands. Fossil fuels are increasingly imported and to that extent vulnerable but they are an indispensable means of satisfying the variable part of the demand. The remaining factor, cost, must then have a large part to play in determining what option or combination of options best suits our need and in what proportions. Many institutions have published estimates of the cost of all these options. A useful presentation is that of the Royal Society of Edinburgh in its “Inquiry Into Energy Issues for Scotland” as follows:

“We conclude that coal, oil, gas, nuclear, waste and biomass (not fuel crops) co-firing all fall within the same cost envelope of 2–3p/kWh with onshore wind at 3–4p/kWh and other options either not yet proved or much more expensive. It should be noted that for fossil fuels, 60% of the cost is in the price of the fuel. Since the costings were carried out, the spot price for crude oil has risen from $35 to $40/barrel to over $70/barrel. ... During this period coal has risen from $35/tonne to around $50/tonne and natural gas from $4–5/MBtu to around $7/MBtu.”

This presentation as a range is helpful; any estimate that pretends to greater precision is specious. Costs are affected not only by capital cost and fuel prices but also by various other factors such as rates of interest and charges under the EU Carbon Trading scheme. These factors affect the various options to different degrees depending upon the proportions of capital cost and running cost. What policy-makers require is that they can be reasonably confident that the judgements

they make on the available figures will not be too far out and still allow some flexibility in practice.

The conclusions are fairly evident:

(i) fossil fuels without carbon dioxide capture and storage are the cheapest option, subject to the uncertainty and instability of world fuel prices;

(ii) nuclear power costs, including the costs of decommissioning and waste disposal and without financial assistance from the Government, are known, relatively stable, and competitive with coal and gas;

(iii) fossil fuels with carbon dioxide capture and storage will be more expensive than nuclear;

(iv) onshore wind-power is more expensive than either nuclear or fossil fuels and offshore wind-power still more so;

(v) marine technologies (wave and tidal stream) are much the most expensive options, even with the benefit of full development.

Recall the Challenge

To increase the Nation's prosperity and welfare while decreasing its greenhouse gas emissions.

Now it is time to make the right decisions...

9 Decisions Decisions Decisions

If it were done when 'tis done, then t'were well
It were done quickly.
William Shakespeare, *Macbeth*

The necessary next step is for the nation's political leadership to accept propositions (i) to (vii) below. The energy industries are in the private sector so the Government's job is to make sure that the financial and regulatory climate is such as to encourage (or at least not discourage) investment compatible with the aims of public policy.

Reform of the stifling planning system for big infrastructure projects is thankfully underway on both sides of the Border but the big policy decisions need to be made and soon.

Public policy is generally agreed to require:

- secure supplies;
- safety of employees and the public;
- environmental protection especially against climate change;
- costs acceptable to consumers and the treasury.

To these ends the technical and economic evidence shows that:

(i) nuclear power should be an accepted option for base-load plant;

(ii) onshore and offshore wind-power should be reappraised, taking account of the costs to the economy (including back-ups and transmission) and potential grid stability effects;

(iii) on-shore and off-shore wind-power should be accepted and subsidised to the extent necessary to meet the UK's international commitments to renewable energy, subject to Scottish environmental constraints;

(iv) fossil fuels, at the most advanced stage of development commercially available, should be accepted to the extent necessary to meet variable system demands and provide back-up for the renewables;

(v) development of carbon dioxide capture and storage should be encouraged by the Scottish Government initially and Scotland should seek to play a major part in the coming UK and EU partnerships;

(vi) development funds should be made available for tidal-stream power up to commercial scale but not necessarily for electricity supply to the grid;

(vii) Proposals to encourage micro-generation whether by financial or regulatory means should be re-considered.

10 The Way Ahead

Thine be ilka joy and treasure.
Robert Burns

We need a clear energy policy if Scotland is to be the pleasant and prosperous country we are striving for.

This paper has examined means of reducing greenhouse gas emissions while providing a secure and economical supply to Scotland's householders and businesses.

The policy that emerges would allow utilities to take full advantage of the positive developments in design, construction and waste management in nuclear power and maintain a large highly skilled technical resource in our country.

It would recognise the indispensable role of up-to-date fossil fuel technologies but would press on with development of their waste management through CO_2 capture and storage.

It would encourage realistic exploitation of the country's renewable resources without being starry-eyed about them.

The bigger task of reducing fossil fuel consumption in other sectors, notably heating, land and sea transport and aviation, has to be tackled. The fact that progress in those sectors may be difficult makes it imperative for the electricity sector to do all it can.

Nor is there time for prevarication – the climate change clock is ticking away.

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