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Reducing Carbon Emissions – the View from 2050

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Foreword for ‘The View from 2050’
Jeremy A Peat

The path to this major David Hume Institute report, and the seminar that follows, all started last autumn, when the Institute ran a seminar and published a paper by Professor Nick Hanley of Stirling University on means to reduce carbon emissions in Scotland.

Nick’s work was excellent and provided an admirable economic framework for considering the various options so far as reducing carbon emissions are concerned. However, Richard Wakeford of the Scottish Government then made a suggestion for a piece of follow-up work that captured my imagination, that of the Institute’s Trustees and indeed that of the wide variety of people who we approached to contribute to this report. His idea was to ask people to consider themselves as being in 2050, with the Scottish Government’s 80% greenhouse gas emission reduction target having been achieved, and to set out how this came about and what were the consequences – as narrow or wide as contributors wished.

It was excellent that the Scottish Government agreed to fund the seminar on this subject and we are extremely grateful to Anne Glover, Chief Scientific Adviser for Scotland, for agreeing to chair that event and also for giving us the benefit of her knowledge and her enthusiasm. I must also thank Philip Wright for his wholehearted support and Nuala Gormley who worked closely and very efficiently with us over the preparations for both seminar and report.

Similarly we owe another huge debt of thanks to Lesley Lilley and the Economic and Social Research Council for agreeing to sponsor this report. The ESRC are long term friends of the David Hume Institute and this is yet another example of their generous support.

The bulk of the work on organising contributions, keeping in touch with (and occasionally chasing) authors, liaising with the Scottish Government, etc was undertaken by the Institute’s Research Officer Lesley Sutton. My thanks to her and to Catriona Laing for organising and delivering this publication.

Like all good ideas Richard Wakeford’s had the benefit of simplicity. Despite the simplicity of the concept, implementation was complex. It proved a huge challenge for us to identify the range and quality of authors who could provide the informed input that was required; and then a similar challenge to the selected authors to fire up their imaginations and bring to bear their expertise in this novel manner.

We went out to a variety of potential authors who could together, we believed, cover the broad canvas. I was amazed at three developments. The first was the willingness of a very high percentage of those we approached to contribute. The concept proved immensely appealing. The second was the sheer number of contributions that proved necessary in order to do adequate justice to the topic. The third was the quality of the contributions. This report includes a diverse set of essays, but their underlying quality is exemplary. All the authors have done us proud!

We tried hard to achieve a balanced set of contributions. We were delighted that Richard Wakeford felt able to give his personal view, as did Patrick Harvie MSP, the Convenor of the Scottish Parliament's Climate Change Panel. (His retiring speech to the Parliament in 2050 is one of the highlights of this report.) Business leaders also came through with important contributions – thoughtful essays from David Watt of the IoD, Iain McMillan of the CBI and Ian Marchant of Scottish and Southern Energy ensure that business has a strong representation. The environmental specialists are here as well – Campbell Gemmell of SEPA, Simon Pepper and Jan Bebbington. Then we have the specialists, Nick Hanley back again as the economist, Sue Roaf on the built environment front, George Hazel (at very short notice so special thanks to George) on transport, Jim Skea on energy and Geoffrey Boulton providing a scientist's perspective. The consumer voice is also here, thanks to Martyn Evans of the Scottish Consumer Council. We saw the voice of younger people as crucial and are delighted with the contribution from our author from the Youth Parliament. Finally, Michael Northcott provides a very special and distinctive insight.

The reader can pick and choose amongst the essays at will. But we felt it necessary to bring out the points of similarity and difference, and provide an overview – again from an informed but – critically - highly accessible perspective. For this we turned to Peter Jones, who last year wrote an excellent paper for us on financial education in Scotland. As a top rated economics and business journalist Peter has delivered an ideal cover note. This in itself makes this publication of value, but I do hope that you will go beyond his admirable contribution to the individual essays. This is a real treasure trove.

As mentioned above we have a fascinating essay from a member of the Youth Parliament. But for the full seminar we decided to progress this issue of contributions from those who will inherit Scotland for 2050. So with the help of the Scottish Government we worked with the Children's Parliament, who extended their WWF Climate Change Project and engaged groups of children and young people from Fife to the Outer Hebrides deliberating our 2050 question. The cover of this report includes illustrations from a mural created by these children that will be on view at 'Our Dynamic Earth' for this seminar. Also we will be showing a video of children's voices at the outset of the seminar. It is only right and proper that those looking forward to their adult lives in 2050 should have their say in this important and so controversial topic. More information on the Children's Climate Change Project can be found at the back of this report.

Further to this last point I must stress that the David Hume Institute, being a free thinking, sceptical and wholly objective organisation, has no view on global warming per se or on the merits of the Scottish Government's targets or the means by which they might be achieved. As ever we see our role as provoking and informing the debate, and I am sure that this report and the seminar will certainly contribute in a meaningful manner to a debate that matters. Your views would be welcome. This topic will remain with us for a while!

Jeremy A Peat
Director

Foreword
Professor Anne Glover

As we look ahead just over forty years to 2050, it is interesting to remind ourselves what life was like if we look backwards the same amount of time to the 1960's. It was very different. How interesting it would have been if the David Hume Institute had decided upon a report and seminar in the 1960's on "The View from 2008". Forty years ago the world was embarking on space travel and exploration of our solar system. In the UK we were marvelling over colour television for the first time, we had installed a new nuclear reactor at Dounreay and were discovering the first oil fields in the North Sea. Would we have been able to predict then that in 2008 we would witness the commissioning of the Large Hadron Collider in Switzerland which supports international research collaboration by fifty countries to allow us to create the conditions prevailing a trillionth of a second after the Big Bang. Understanding the fundamental nature of matter is within our grasp. Would it have seemed possible that our walls would be decorated with plasma screen TVs receiving a multitude of channels which we could record and play any time we wanted and that we could access and send information almost instantly around the world? What we did look forward to was a supply of sustainable energy being delivered by the newly discovered oil fields of the North Sea. We didn't give much thought to the environmental cost.

So what is the value of looking into the future to imagine what our lives might be like in 2050 and how we might have met current energy challenges and what new ones we might have encountered?

Human survival on the planet depends upon our ability to imagine, to be aspirational in what we want for our future and then to apply our thinking to develop the means of how we might get there. At the moment there is a lot at stake but we can give ourselves the best chance of a future on the planet by continuing to grow our science engineering and technology base. Without this platform we will be lost. But biological and physical sciences cannot deliver on their own; we need much more integration with social science and economics. We need future generations of engaged, scientifically literate people who know what questions to ask and are able to appreciate risk and uncertainty. Science, engineering and technology can be part of a solution but cannot deliver without a society that is prepared to be challenged by new technologies and able to respond to difficult choices.

This major David Hume Institute report is exciting, timely and captures some of our best thinking from the wise to the provocative. It is the catalyst for debate and that is what all good thinking thrives upon. I hope as many people as possible are stimulated by the essays in this report and use the ideas to create their own imaginative pathways to 2050.

Professor Anne Glover
Chief Scientific Adviser for Scotland

Imagineering 2050 emission-lite Scotland

Peter Jones

The essays in this volume are not forecasts. Forecasting is a truly hazardous art. Libraries are littered with books that got it wrong, and thinly populated with volumes that got it right. Rather, these essays are an exercise in imagineering, a word coined in 1940s America and defined as “the fine art of deciding how we go from here”.

No single contribution should be taken as plotting the “right” path by which Scotland can reach the target of cutting greenhouse emissions by 80 per cent by 2050. That is not the purpose. The object, instead, is to set out various scenarios from different perspectives – environmental, business, economic, consumer, academic – for what might be done over the next four decades. No attempt has been made to produce a consensus view for there is a risk that such a consensus might crowd out alternative viewpoints and suppress radically different strategies when they, indeed, might have the right perspective. The history of science teaches us that the accidental discovery, the flash of insight, and the “wrong” approach are almost as important in advancing scientific knowledge as planned and programmed research.

Understanding this is particularly important when the world’s population and its governments are confronting the problem of climate change. This is unlike any other problem humanity has encountered. Mitigating and reversing the processes which are helping to cause climate change requires stopping, or at least greatly reducing, something which, ever since the Industrial Revolution, has been assumed to be a pathway to greater human prosperity and happiness – the burning of the fossil fuels of oil, coal, and gas.

Achieving that requires radical and perhaps painful actions. It requires re-thinking industrial processes, how all of us go about our daily lives, and how we make social and political decisions. And it demands unprecedented global as well as national and individual action.

This introductory essay does not attempt to draw definitive conclusions. Its purpose is to gather together the common and conflicting threads, the agreements and antagonisms, and the different dimensions to the debate to present an overview which sets out some of the challenges we face and the choices we will have to make if we are to reach the 2050 goal. So first of all ...

What is the scale of the task?

The aim is to reduce Scotland’s greenhouse gas (GHG) emissions by 80 per cent of their 1990 levels by 2050. In 1990, Scotland is estimated to have produced 64.4 million tonnes (mt) of carbon dioxide equivalent (CO₂e).¹ So in round terms, Scotland has to get that down by 51.5mt to 12.9mt. Most, but not all of this, is carbon dioxide (CO₂), accounting for 50mt or 77.6 per cent of the total. The remainder mainly comprises methane (8.2mt, 12.7 per cent) and nitrous oxide (6.2mt, 9.6 per cent).

¹ Scottish Government. *Key Scottish Environment Statistics 2008*. Edinburgh. August 2008. Page 12. Available at: <http://www.scotland.gov.uk/Publications/2008/08/19084547/44>

Scotland seems to be making good progress towards reducing these greenhouse gas emissions. By 2005, total greenhouse gas emissions were down to 54.6mt, a reduction of 15.4 per cent. It puts Scotland 54th in a world league table – between Hungary and Columbia - of greenhouse emissions by 206 countries.² Carbon dioxide emissions were reduced to 43.8mt (down by 12.4 per cent) methane emissions cut to 5.1mt (a cut of 37.8 per cent) and nitrous oxide emissions had fallen to 4.9mt (down by 21 per cent). Only another 42mt to go then.

How did this reduction come about? The carbon dioxide reduction mainly occurred because of changes in the economy – the disappearance of steel-making, for example – and, since these are net emissions, an increase in afforestation helped the consumption of carbon. Closure of deep mines reduced methane emissions and landfill rubbish tips also produced less methane. Changes in agriculture meant there was less nitrous oxide from fertilizers.³

Throughout this period, the Scottish economy grew by about 33 per cent. So one lesson is that it is clearly possible to have both economic growth and to cut greenhouse gas emissions. However, a second lesson is that some of the events which have led to these cuts were painful – the closure of deep mining and of the Ravenscraig steelworks, for example. Knowing this, we can also understand that the emission cuts were accidental or unintended consequences of economic change.

That means that emissions can also accidentally rise again. Indeed, there was a 5.4 per cent rise in emissions in 2006, mainly due to a switch to coal-fuelled electricity generation caused by a rise in gas prices.⁴ This tells us that the price of the energy we consume matters a lot more than its emissions output.

In an individual basis, the task looks even more onerous. In 2005, each Scot produced about 10.7 tonnes of CO₂e. That ranks us about 50th in the world league table of greenhouse gas emissions per capita, alongside Japan (also an advanced industrial nation) and Myanmar (where there is large-scale destruction of forests). To meet the 2050 target, that will have to come down to about 2.6 tonnes of CO₂e, of which about 2 tonnes will be carbon dioxide. That assumes a Scottish population of 5.1 million; if the population is bigger than that, the per capita consumption will have to be lower.

What answers do our contributors have to the question ...

How will change come about?

There is general agreement that while governments can set targets for reducing greenhouse gas emissions and create mechanisms for achieving those targets, they will be ineffective unless their citizens accept the need to move in this direction and adapt their behaviour accordingly. Ian Marchant says that the world will change “because of changes in attitude and behaviour and the human capacity for ingenuity and survival.” Martyn Evans adds that “consumers and citizens [are] the only effective solution to the challenges and not the problem”. But ...

² See http://en.wikipedia.org/wiki/List_of_countries_by_carbon_dioxide_emissions

³ Scottish Government. *Second Annual Report on Scotland's Climate Change Programme (April 2007-March 2008)* Edinburgh May 2008. Page 3. Available at:

<http://www.scotland.gov.uk/Publications/2008/05/20102350/0>

⁴ Scottish Government. *Scotland faces emissions challenge* Press Notice September 18, 2008

What will drive this change?

Fuel prices. The writers are generally agreed that the rise in oil prices seen in 2008, peaking at \$147 a barrel, with consequent price rises in gas and oil, are but harbingers of further price rises to come. Simon Pepper contends: “Energy prices provided the explosive charge behind a transforming surge in policy, rising to \$200 per barrel (after some ups and downs) – often more than a \$10 rise in a single day.” Michael Northcott is more apocalyptic: “The price of oil rose from \$300 to \$900 a barrel between 2012 and 2025 and for most people driving and flying became too expensive.”

I would caution against pinning too much belief in ever-escalating oil prices, at least in the short-term. When prices rise, demand falls, a phenomenon seen in the USA this year when demand for gasoline fell to 2002 consumption levels. That was outstripped by the rise in consumption in non-OECD countries, the biggest consumers being China and India where fuel prices are subsidized. Globally, subsidies amount to about \$300 billion, the bulk of them being paid in China and India.⁵ Such subsidies are unsustainable at high prices, meaning that consumers currently benefitting from them will surely feel our pain sooner or later and cut their consumption accordingly.

Nevertheless, even on some conservative oil price forecasts of \$50-80 a barrel⁶, much higher oil prices than we have been used to are evidently here to stay, though whether they are quite the high-pressure driver suggested is debatable. Nevertheless, the other side of the price coin is ...

Cost savings. The Youth Parliament point out that when there is much greater public realisation that money can be saved by being more efficient with energy, adoption of measures which cut emissions will become more widespread and second-nature. “Provision and fitting of insulation for elderly peoples’ homes and mass production of reduced cost energy-saving light bulbs brought this way of life straight to the public ...” and “...the push for all new homes to be built with energy efficiency in mind ...” will, the Youth Parliament thinks, do much to educate the public towards a low-carbon economy. Besides these domestic pressures, there is the wider strategic question of ...

Security of supply. Ian Marchant, accepting that fuel prices will rise, contends that there will be increasing dislike of reliance on distant sources of supply in faraway, unstable countries and that there may even be regional wars over scarce resources. This, he says, “brought home the reality that energy security delivered by more local, sustainable resources was an important part of national security.” Some of this is already happening: rumours of any new tensions in the Middle East prompt spikes in oil prices and Russia seems to have begun using its large gas exports as a lever to attain political objectives, notably to mute western European responses to the conflict in Georgia. But as well as man-made difficulties, nature is also causing ...

⁵ United Nations Environment Programme. *Cutting Fossil Fuel Subsidies Can Cut Greenhouse Gas Emissions Says UN Environment Report* Press Release, 26 August 2008. Available at:

<http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=543&ArticleID=5902>

⁶ Thorsten Fischer. *Crude Oil: when will the bubble burst?* March 2008. Royal Bank of Scotland Group Economics. Available at: http://www.rbs.com/economic03.asp?id=ECONOMIC/WORLD_ECONOMY

Weather catastrophes. The rain which has drenched and locally flooded much of Britain in 2008, hurricane Katrina which swamped New Orleans in 2007, the droughts afflicting Australia and much of Africa, are all pointers to climate change which has already begun with dreadful consequences. Most of the writers believe that much worse is to come.

Geoffrey Boulton believes that accelerated flow in glacier ice streams in the polar regions will cause sea levels to rise much faster than predicted, at about 2cm a year by 2012. “The imminent threat to vast areas of highly populated lowlands became very clear, with the potential demise of the Netherlands, Bangla Desh, Kuwait, and flooding of large areas of the US Gulf of Mexico, Florida and east coasts of Myanmar, Thailand and NE China, etc. Large parts of south-eastern England, and in Scotland, the Forth, Clyde, Moray and Solway lowlands were clearly at risk.”

Simon Pepper is no less pessimistic. Contending that an increase in average global temperatures of 2°C will occur by 2050, when many climate scientists believe that a tipping point of irreversible climate change will occur, he says: “Storm, flood and drought set off the deadly dominoes of hunger, migration and political unrest throughout the developing world. Europe and the US, and prosperous enclaves in other countries world-wide, began to bar the fortress gates, fearing the hordes.”

Campbell Gemmill thinks this may occur earlier. “I think it was one of the sequence of devastating heat waves in the US North-east and across north-west and central Europe that finally did it, coming on top of the dramatic coastal damage in the 20s after the final decline of the Greenland Ice Sheet triggered the collapse of what was left of the West Antarctic Ice Sheet. That extra 3 metres sea-level rise did the trick.”

It is always possible that these things won't happen. But the increasing flurries of straws in the wind, such as the north-west and north-east passages around the extremities of the Arctic Ocean becoming navigable in 2008, strongly suggest that they cannot be ruled out either. One missing element from these scenarios is that if they occur, even only to milder degrees, then additional costs will be imposed on the insurance industry, to the point that some companies may be bankrupted and lots of properties may become uninsurable, something which will surely impact on public thinking, as will ...

Population growth. Even if individuals' demands for energy, transport, food and shelter were to remain constant at 2008 levels, world demand for all these things will continue to increase because of population growth. In 2008 the world population reached 6.7 billion, a two-and-a-half fold increase since 1950, and the proportion living in urban areas grew to 50 per cent.⁷

The writers' projections for the world population in 2050 range from 8 billion (Pepper) to 10 billion (Gemmill), a 20-50 per cent increase. Even though much of this increase will occur in countries which have low per capita greenhouse gas emissions, it still implies a worsening climate change problem. It also implies an extra demand on the earth's resources, whether these be oil, steel, or rice. Consequent price rises are liable to send a strong message to all people that the world is facing serious problems requiring urgent action.

⁷ Population Reference Bureau. Available at:
<http://www.prb.org/Publications/Datasheets/2008/2008wpds.aspx>

In Scotland, which has a relatively high per capita carbon output, government objectives of population growth, if achieved, mean that the 80 per cent reduction goal will become more difficult to achieve.

Brakes on change

All forces which demand change have opposing forces. So it is with climate change. What forces are there which resist change?

Denial. A good many people do not accept that human activity is causing climate change. Pepper refers to an Ipsos Mori opinion poll, reported in the *Observer* newspaper in June 2008. It found that the British public have mixed and contrary views about climate change: 45 per cent believed it was the most serious threat facing the world today but only 9 per cent thought it would impact on them personally. The *Observer* reported that although 2,500 scientists for the UN Intergovernmental Panel on Climate Change (IPCC), found a 90 per cent chance that humans were the main cause of climate change, this poll found that 56% of Britons thought that the scientific jury was still out on the cause.⁸ As Richard Wakeford observes: “It’s been surprising how many natural disasters on the scale of the flooding of New Orleans have still left people in denial about the need for action.”

It may be, however, that pollsters and social scientists have not yet found an accurate gauge of public opinion on climate change. A Globescan survey for the BBC World Service in September 2007 (perhaps when hurricane Katrina was fresher in the memory), found that across 21 countries, an average of 79 per cent of respondents (70 per cent in Britain) agreed that “human activity, including industry and transportation, is a significant cause of climate change”. And perhaps the reason for apparently contradictory public attitudes lies in ...

The China evasion: Pepper coins this term to characterize an attitude which recognizes that climate change is a big problem but whatever one person does in response is bound to be wiped out many times over by the huge and increasing greenhouse gas emissions of China. The point is made by Nick Hanley who says that even if Scotland achieves its 80 per cent target by 2050, this will make a “vanishingly small” contribution to reducing global emissions. “Currently, Scotland’s emissions account for 0.15 per cent of global greenhouse gas emissions, and this fraction will fall as emissions from countries such as China and India rise,” he notes. The Ipsos Mori survey found that 33 per cent of those polled thought they had no influence at all on work to combat climate change. This attitude helps to contribute to ...

Green conflicts: Jan Bebbington says: “We had the technology to produce energy from wind but were witnessing high levels of resistance from many communities to have wind clusters or wind farms sited near to them.” Developing renewable wind energy tends to put two green objectives in conflict with each other – the beauty of an unspoiled landscape versus wind turbines despoiling the landscape. The same conflict is apparent in opposition to the upgrading of the Beaully-Denny high voltage transmission line, necessary if Scotland is to harvest Highland wind. Whether this same conflict in the debate about nuclear energy develops in the same direction seems more debatable.

⁸ Juliette Jowitt. Poll: *Most Britons doubt cause of climate change*. The Observer, June 22, 2008. Available at: <http://www.guardian.co.uk/environment/2008/jun/22/climatechange.carbonemissions> and Phil Downing and Joe Ballantyne. *Tipping point or turning point: social marketing and climate change*. Ipsos Mori, June 2008. Available at: <http://www.ipsos-mori.com/reportsandpublications/socialresearch.ashx>

Patrick Harvie thinks that just as ‘peak oil’ (when the production of oil goes into terminal decline) will be reached within the next decade, so too, if the world rushes into expanding nuclear energy production, will peak uranium occur in the 2020s. Yet some environmentalists have begun to see the fact that nuclear power produces very little greenhouse gas emissions as more important than the fact that it produces radioactive waste with long-term storage problems.⁹ Only one writer breaks the consensus that Scotland will remain anti-nuclear. Evans suggests that the final push to meet the 2050 target will come in the 2040s when a decision will be made, using technology which has solved many current problems, “to deliver a new generation of nuclear power plants.” Regardless of whether such attitude changes occur, there remains the problem of ...

The planning system: The business contributors are unanimous in identifying barriers in planning – the system by which companies and householders get permission to build large and small renewable energy projects – as slowing down the shift towards renewables. David Watt talks of backlogs of queues of people trying to get permission for micro-renewable schemes as does Marchant. Iain McMillan says: “We will need to realize a streamlined planning system that delivers the necessary low carbon generation capacity in a timely manner.” One report says that wind farm developers have to wait on average for 33 months for government decisions on big wind farms, and small developers have to wait 20 months on average for decisions from councils.¹⁰ Hydro schemes face similar delays. If this gets resolved, there is still a question of ...

Price: Although rising energy prices are a driver towards lowering greenhouse gas emissions, price differentials between different technologies involved in generating electricity work against renewable generation. One study, for example, by the Royal Academy of Engineering, estimates the costs of electricity generated by conventional means at 2.2-3.2 pence per kilowatt hour (p/kWh) against 3.7p/kWh for onshore wind and more than 6p/kWh for biomass, offshore wind, wave, and tidal power.¹¹ To make renewables economic, the British government introduced the renewable obligation scheme which exacts a levy on conventional generation to distribute as a subsidy to renewable suppliers. This levy, about £10 on the average domestic bill in 2008 is expected to rise to £20 by 2015.¹² So far this does not seem to have caused much public disquiet. But above that is the prospect of carbon pricing and taxation, which would impinge much more widely, covering, for example, transport and vehicle fuel prices. Nick Hanley argues that establishing a price on pollution is essential to enable market mechanisms for reducing greenhouse gas emissions to function. “However,” he notes, “as evidenced by recent political responses to the fuel duty escalator in a world of rising oil prices, carbon taxes would be a very hard sell.” A rudimentary carbon taxation scheme does exist – the European Union’s Emissions Trading Scheme. However imperfect, it has established the principle that emitting greenhouse gases carries a cost.

⁹ See, for example, George Monbiot. The stakes could not be higher, everything hinges on stopping coal. The Guardian. August 5, 2008 Available at:

<http://www.guardian.co.uk/commentisfree/2008/aug/05/kingsnorthclimatecamp.climatechange>

¹⁰ Rob Edwards. Wind farms in Scotland face prolonged delays. Sunday Herald. 20 January 2008. Available at: <http://www.robedwards.com/2008/01/wind-farms-in-s.html>

¹¹ Royal Academy of Engineering. *The Costs of Generating Electricity*. London 2004. Available at: <http://www.raeng.org.uk/policy/reports/electricityreports.htm>

¹² Ofgem. *Household Energy Bills Explained*. Factsheet 66. Available at:

<http://www.ofgem.gov.uk/Pages/MoreInformation.aspx?docid=73&refer=Media/FactSheets>

Hanley adds an extremely important point: “Moreover, the Scottish government’s ability to enforce its own carbon tax is very limited.” This, I suspect will become an important political debate in the years ahead – which jurisdiction should have the legal competence to enforce rules on emissions and to impose penalties for breaching them: the EU, the UK, Scotland, or perhaps some as yet uninvented world or supranational body. And if Scotland, whether devolved or independent, chooses to set higher targets than those laid out in international agreements, can those targets be legally enforced?

Nevertheless, it still remains to be seen how much cost society is willing to bear, both in monetary and judicial terms.

What may tip the balance towards action on climate change?

The writers seem generally confident that a combination of human actions (mainly rising energy prices) and natural action (climatic cataclysms) will do the trick. The price imperative, reckons Sue Roaf, will turn energy inefficient buildings into “an investment nightmare in the tumultuous markets created by soaring energy prices.”

Marchant expects that the climate imperative will make green conflicts over the visual impact of wind turbines disappear: “The professionalised environmentalists played an increasingly leading role as they realised that climate change threatened everything – and the arguments of some of their own, to oppose all wind farms as ‘blots on the landscape’ for example, became untenable.”

Political leadership is also important, he thinks: “Positive action came when leading politicians put forward a compelling message that economic prosperity depended on environmental stewardship.” And he considers, perhaps more in hope than expectation that rational fact-based debate will triumph over opinion and “ill-informed shouting matches.”

What tools are needed to build an emission-lite Scotland?

Top of the list, and referred to by several writers but most explicitly by Hanley, is ...

Carbon pricing. The production of carbon dioxide is what economists call an ‘externality’. Externalities can be positive, but in the case of greenhouse gases, they are negative or are an ‘external cost’. This means that it is something which results from a purchase or a process undertaken by one group of people and which has an effect on other people whose choices or interests were not taken into account. Thus the external cost of buying a tankful of petrol and using it is pollution which causes fumes in the locality of the petrol-user and adds to global pollution levels. A conceptually simple way of dealing with this is to make the petrol-user pay the cost by putting a price on the pollution and incorporating that into the price of petrol. This should deter people from using petrol and, in theory at least, the money raised from those who continue using petrol can be spent to reduce the effects on other people.

The production of carbon is now recognized as having a major external cost and one of the principal conclusions of the Treasury's review of the economics of climate change under Sir Nicholas Stern was that "establishing a carbon price, through tax, trading or regulation, is an essential foundation for climate change policy".¹³ In ideal world, as Hanley says, there would be a global price on carbon. That seems a long way off, but in the meantime there is the EU Emissions Trading Scheme which does put a price on carbon, and within which any Scottish climate change strategy has to fit. It is much criticized for prices which are too low. Some countries – Denmark, Norway, the Netherlands, Finland, Sweden – have, since the 1990s, introduced national carbon taxes, but the effects have been mixed.¹⁴

Hanley contends that the Scottish government could use its limited powers and leverage to argue that the EU scheme should be extended to cover emitting sectors not presently covered, to allow land managers to act as suppliers of carbon credits (controversial with environmentalists), and for a reduction in the supply of permits. He also reckons that prices need to be set for other negative externalities such as methane and nitrous oxides, congestion, and the effect of wind farms and transmission lines on landscape and wildlife.

But, instead of just taxing externalities, should we be prepared to think rather more radically? There may be a case for an ...

Ecological tax base. Bebbington raises this idea tantalisingly briefly, suggesting that we might move towards this in 2017. Our current taxation system is geared towards the taxation of wealth and the rewards – income, profits – of creating it. An ecological tax system would abandon such taxes, and shift towards taxing activities which detract from the ecology of the planet, such as the extraction of hydrocarbons and the burning of them. Activities which are ecologically neutral, such as the planting, harvesting and burning of biocrops would attract no tax. Activities which are ecologically positive, such as the planting or enhancement of native vegetation, might enjoy a subsidy. Such a tax system would ramp up the costs of ecologically harmful activities, especially those emitting greenhouse gases, quite sharply and focus attention and resources on eliminating such activities. That appears to be the outcome expected by Bebbington.

A variation, which is my own suggestion, and which is equally radical would be to abolish all existing consumption taxes – VAT, fuel duties, air passenger duty – and replace them with a greenhouse gas tax, or GGT. The rationale behind this goes back to the over-riding priority identified by the contributors – to change attitudes and behaviours. The best way of doing that is to exact a tax at the point of consumption which would be levied according to the amount of greenhouse gas emissions caused by the creation of the product or service. Hydrocarbon fuels would attract a high level of tax, renewable electricity for the powering of electric vehicles a low level. Mangos air-freighted from Africa would be highly taxed, strawberries from Tayside lowly taxed; concrete buildings would carry a high tax tariff, wooden buildings a low tariff, and so on.

¹³ HM Treasury. *The Stern Review: The Economics of Climate Change Policy*. London 2006. Page xviii. Available at: http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/sternreview_index.cfm

¹⁴ A useful summary of the taxes and their effects has been prepared by the US Environmental Protection Agency and is available at: <http://yosemite.epa.gov/EE/Epalib/incent.nsf/c484aff385a753cd85256c2c0057ce35/0483a144da8fa434852564f7004f3e68>

Exceptions might have to be made on health grounds for special duties on tobacco and alcohol (both relatively carbon neutral products) but otherwise, and provided the levels of GGT were transparently identified (much as VAT is now) such a tax could have radical effects. Admittedly, identifying the carbon content of each item might be excessively bureaucratic and prone to fraud but in my view, no suggestion should be summarily rejected at this stage.

This last point raises the question of the degree of required ...

Regulation. Hanley counsels against over regulation, arguing that if government sets too many sub-targets within the overall 80 per cent reduction target, flexibility will be lost. For example, he criticizes the Scottish government for setting the sub-target of generating 50 per cent of Scotland's electricity requirements from renewables. The evidence is, he says, that this is an expensive way of reducing carbon emissions. He argues: "Much better for the Scottish government to set the overall target, establish a menu of economic incentives which encourages this to be achieved, and then let firms and households decide on their own best response."

The other contributors generally agree. Skea envisages that a future government might impose obligations on energy suppliers that entailed them having compulsory access powers to install insulation, solar thermal heating and triple-glazing. Civil disobedience and communities barricading themselves against police and utility workers could well be the outcome, he imagines.

One interesting exception to the light regulation rule is proposed by McMillan. He suggests that a relatively fast way to reduce greenhouse gas emissions is to make a distinction between the upstream (generation) and downstream (consumption) parts of electricity production and use. The responsibility for emissions could be limited to generation and industrial sites, while households would only be able to use electricity and not oil, gas, or coal. Household action on climate change would then be limited to energy efficiency, he suggests.

This idea focuses attention on an area where there are sharp divisions between the contributors. This is whether the best way to reduce emissions is by ..

Government action or market mechanisms. A distinctly sceptical tone when assessing governments' willingness to take the hard decisions needed to mitigate climate change pervades many contributions. Harvie, perhaps unsurprisingly, is scathing about ministers proclaiming their climate change credentials while approving greenhouse gas-multiplying motorway and airport runway projects. Less predictably, Marchant is dismissive of political leaders announcing grand targets which are way beyond their time of office. One exception is Skea's imagining of a key turning point – a European Commission decision about 2020 to take court action against all member states failure to meeting undertakings on the deployment of renewable energy. Perhaps such action is easier when the decision-makers are appointed, not elected, a point made, rather worryingly, by Pepper: "The democratic excess of denial and delay was inviting catastrophe. China's command regime – ever the contrast – moved swiftly ahead with dramatic energy efficiency targets ..." Gemmell, thankfully, sees a quite different scenario: "The democratisation of the biggest country on earth ... brought the largest, smartest and most active population to bear on the scale of innovation that Seattle and southern California had shown at the end of the 20th century, but 50 to 100-fold ..."

Equally extreme views are expressed about market mechanisms. Watt, for example, expects many to be surprised that “the private sector led the charge to cut greenhouse gases and did not have to be penalised through taxation or legislated into action. The dual factors of market forces and business opportunities were the biggest drivers ...” Against that, several, citing the Stern review, insist that climate change is the greatest market failure the world has seen. Evans posits further failures, imagining that a ‘CarbCard’ scheme to permit carbon trading by individuals may balloon then burst: “The ‘CarbCard Bubble’ as it came to be known, collapsed in acrimony within five years of its launch in 2025, accusations of fraud, scamming, manipulation, freeloading, speculation, and elitism all taking their toll.”

And yet the broad picture which emerges from the contributions is that governments, people, companies, social groups all have a job to do in much the same way as they do now. Watt, despite his espousal of the free market, expresses it well: “We have achieved our targets ... due to government taking key structural and organizational culture moves; business being creative, inventive and innovative; and finally individuals reacting positively ...” Watt also believes that we need a ...

Streamlined planning system. He reckons this will come in the next decade when there will be “a national planning agency to replace what had previously been known as the planning service” and the government will give it a “clear focus on bringing Scotland up to world class in terms of getting projects approved and completed quickly and efficiently”. Marchant also sees a planning system which “helped rather than hindered” But some writers also think we need a ...

Participative public and political decision-making system. Bebbington introduces the idea of advances in ‘social technologies’ encompassing the rules used to make decisions, models of thinking in government, approaches towards taxation, and how individuals and groups interact with each other. Wider groups of people, she suggests, will become involved in longer and more extensive discussions. One such method could be the creation of a virtual parliament accessible to all which, she believes will lead to political leaders becoming “respected and trusted” and “our democracy [becoming] more democratic”. She contends this will be important in facilitating individual and, more importantly, collective behaviour change, especially in a huge array of social experiments aimed at achieving low-carbon living.

Evans also sees potential for the same sort of development, but coming through the internet and vast increases in computing power. The internet, he suggests, will result in a shift in popular culture from consuming to participation which will democratize innovative science. Collaboration amongst large groups of people – inventors, university academics, bankers – may, he thinks produce dramatic innovations such as light-weight and high-power batteries. Politicians, however, may need pressure applied on them through ...

Legislative Obligations. Wakeford points out that politicians can pass laws to, say, require double-glazing, but the policy can have little effect if people leave the windows open. Marchant suggests that it may be time to close the politicians’ windows: “Legislation which made politicians more accountable before each election for their actions in climate change and energy also concentrated the political mind wonderfully.”

If all, or even just some of the above, happens ...

What will Scotland look like?

The short, and not very helpful, answer is that in some ways, Scotland may be very different and in other ways it may change very little. In approaching this part of this essay, I decided to present it according to a rule of thumb I adopted after reading a number of reports on climate change including the Stern review. This is that the most rapid progress towards reducing greenhouse gas emissions will occur where the necessary measures are cheapest and produce most economic benefit. One report I found very helpful was prepared by McKinsey & Co, a consulting firm, on greenhouse gas emissions in America.¹⁵ While the Scottish economy is different, it is also an advanced economy which means the McKinsey conclusions are still relevant.

The report researched the economics of greenhouse gas emissions across the whole range of economic activities and found that costs and benefits cutting emissions varied enormously. It concluded that there were five clusters of activities with potential for greenhouse gas abatement. Ranked in order from lowest to highest average cost of abatement, the five clusters were:

1. Improving the energy efficiency of buildings and appliances.
2. Encouraging higher energy efficiency in vehicles while reducing the carbon intensity of transportation fuels.
3. Pursuing a range of targeted measures across energy-intensive portions of the industrial sector.
4. Expanding and enhancing carbon sinks.
5. Reducing the carbon intensity of electric power production.

The finding is a bit of a surprise, for the current environmental debate in Scotland is dominated by discussion of how to increase the output of electricity from renewable sources such as wind and hydro power. Yet, according to the McKinsey findings, this is the most expensive course of action. Given that energy prices have risen sharply in 2007-08, and that renewable energy is expensive to produce (indeed, it requires a subsidy) relative to conventional generation, it seems reasonable to think that the attention of individuals, companies, and other organizations is now much more sharply focused on reducing energy use. This fits with the McKinsey cost rankings given above. So, let's begin with ...

Buildings and appliances. The most extraordinary insight into buildings and their energy efficiency is offered by Roaf who says that much commercial property has been built with features more intended for the profit of third parties than the convenience of owners and users. "For instance," she says, "the lighting profession had developed standards that required excessive lighting." But, she argues, by making use of solar power and other technologies, it is possible to construct buildings that run on tiny amounts of energy with 90 per cent less emissions than at present. High energy prices and climatic stress should push construction decisively in this direction by the 2020s. "Even in rainy Scotland, the myth was proved very wrong that there is not enough sun in northerly latitudes to make solar energy worth the investment," she says.

¹⁵ McKinsey & Co. *Reducing Greenhouse Gas Emissions: How Much at What Cost?* December 2007
Available at: <http://www.mckinsey.com/client-service/ccsi/greenhousegas.asp>

On domestic residential buildings, there is a striking unanimity of opinion on the way to move towards low-carbon energy efficiency. Marchant argues that energy firms will no longer just produce energy, but will have to become energy service companies – selling the means to use energy well in addition to producing it. Smart meters (which tell a consumer the cost of energy used, potentially for individual rooms and devices) may become mandatory and household microgeneration will proliferate. Skea, along with others, foresees energy companies working in partnership with local authorities and other organizations to equip houses with energy-saving materials and help people save money. He offers the intriguing thought: “Eventually, profligate energy use was stigmatized in the way that tobacco use and drink driving had been in the past.”

Skea also believes that electrical appliances will also become much more efficient, that their stand-by mode when they consume power while “off” will disappear, and that advances in digital and communication technology will dramatically reduce the amounts of power used in communication.

All this sounds exciting. But as Hanley warns, greater energy efficiency does not necessarily lead to less energy use because of what is called the “rebound” effect.¹⁶ In simple terms, where an individual, business, or company uses low amounts of energy because it is too costly, greater energy efficiency may reduce their energy bills and so enable them to use more energy. Moving on to ...

Transport. Most of the contributors agree that the age of the fossil-fuelled vehicle is now coming to an end. There will be a conversion to fuel-efficient vehicles perhaps accompanied by a rise in the use of bio-fuels (debateable given that recent increased bio-fuel cropping appears to have contributed to food shortages) ending in a shift to electric vehicles (depending on advances in battery technology). Marchant offers the enticing prospect of petrol-head adoration of BBC TV’s *Top Gear* being replaced by electro-brain adulation of *Top Volt*. But there is a division of opinion regarding the end result. Some think car use will be limited to sharing via car clubs (Bebbington, Pepper), others that electric car ownership will still be widespread (Skea, Evans). One consequence of this, points out Hanley however, will be a rise in the consumption of electricity though whether this outweighs reductions through efficiency gains elsewhere cannot be determined. Public transport and high-speed trains will become much more important, but again there is a division over whether air travel will survive. Northcott suggests the exciting concept of solar-powered airships using “spray-on solar cells that were used to coat the helium-filled airships.”

But the most dramatic vision is set out by George Hazel. We will be able to route plan journeys according to their monetary and carbon costs, he believes, using a personal mobility planner. It, when we input our start and end points, will tell us all the possible permutations of how to make that journey. Mobility, far from being restricted by fuel and carbon costs, will be enhanced and people will be able to make their own decisions on how to minimise the carbon output of travel rather than having such decisions taken for them. There also appears to be an equally optimistic view of the prospects for ...

¹⁶ For a useful account, see <http://www.carboncommentary.com/2007/11/11/51>

Industry. While there is a sense in some contributions that industry will need pushing by government action and subsidies towards reducing their energy demands and carbon output, it is striking that the business contributors speak of a strong will to head in these directions anyway. Watt says that rising costs will force companies to cut their energy and carbon tax bills, but McMillan says it will go beyond mere cost-cutting to new business models: “Efficient and effective carbon management within the business and also down supply chains will reduce costs and wasted energy and so become the new token of a successful business.” New low-carbon technologies, particularly when there is a global price for carbon, will lead, for example, to low-carbon steel production. New markets for such technologies will open up and could be worth \$1 trillion within five years of a global deal limiting greenhouse gas emissions. McMillan points towards industrial systems where energy through the industrial process is recycled so none is wasted and the development of a ‘green collar’ skills sector driven by rising demand for specialist environmental skills.

Watt, in common with some environmentalist contributors, sees a shift to different working patterns towards home and remote working by company employees: “Big offices began to shrink and local became good.” Skea lauds the luxury of being able to work at home or at the community tele-hub. Watt agrees with McMillan that there will be new business opportunities and contends that Scotland could “lead in Europe, if not the world, in developing the ideas and technology to make carbon efficient energy production turn from dream into reality”. Hanley says that government can assist with this, not by trying to pick technology winners, but by incentivising research and development and the uptake of new technologies. The general point is that provided government gets the tax framework right, there are big opportunities for business and economic growth while reducing business carbon footprints. Big though these opportunities are, even bigger ones may await the ...

The countryside and carbon sinks. No-one has any doubt that the countryside and agricultural production will change dramatically, but there the unanimity ends. A dilemma, Wakeford delicately suggests, is faced by livestock farming because of rising costs of grain feed and methane emissions from animals. Northcott contends livestock numbers will be substantially reduced (helping to cut emissions) but dairying, because of the discovery of feeds that reduce methane emission and transport costs rendering milk imports uneconomic, will become highly profitable. Sporting estates will have to get rid of deer, he suggests, because the weight of deer turns soils from carbon sinks into carbon emitters. Estates, he reckons, will benefit from carbon credits by replanting indigenous forests, a vision shared by Watt and Evans. Wakeford cautions that the EU Common Agricultural Policy, which Evans thinks will be abolished, perversely discourages upland tree planting. Pepper also believes that any tree planting resulting from carbon off-setting (planting a tree to compensate for carbon produced, say, by a plane journey) will be short-lived as legislators realise that such trades create a moral hazard (people come to believe there is no environmental harm caused by air travel so long as lots of trees are planted). Skea thinks new crops (Evans suggests Tayside vineyards) will become viable. Northcott sees transnational imports of food disappearing as African and Asian countries turn away from imports to self-sufficiency, a trend that will manifest itself in Scotland by cities and towns becoming surrounded by wide greenbelts of allotments “where urban dwellers grow much of their own food, keep chickens and pigs in free-range common areas, and camp out on long summer evenings.” Gemmell bets that the proportion of the workforce involved in food production will rise from 1.5 per cent to nearly 40 per cent. Farmers, he thinks, will become carbon stewards.

Most writers think that these changes, plus a drive for community-based renewable energy sources, will make for growth in rural businesses and communities which, reckons Evans, will also benefit from new leisure pursuits such as electro-cycling and from expanded timber production. The new opportunities, avers Pepper, will make rural Scotland more densely populated than at any time in the last 5000 years. But, whether living in town or on a farm, people will still need ...

Energy. No-one has any doubt that electricity generation from renewable sources will expand, but there is uncertainty about what form it will take. There does not appear to be, as Gemmell remarks, a magic bullet solution. This is entirely understandable, as in 2008, the only commercially proven technologies are onshore wind (albeit with subsidy) and hydro, for which there is only scope for minor expansion. Offshore wind, wave, tidal, and the non-renewable but low-emission carbon capture and storage technologies in 2008 are all still at development stage and some way short of being proven to be viable. Bebbington fears we may back some ‘loser’ technologies – the unintended adverse consequences of biofuels being an early example. Skea sees carbon capture and storage eventually gaining market credibility until 2030 but never meeting “purist” demands for zero-carbon output. Pepper thinks it will be the mid-2020s before renewables make a serious impact. Boulton fears that the engineering problems of carbon capture may prove too intractable and that the strategy of relying on this and other renewables is high risk.

Yet the task is urgent. McMillan emphasises that over the next 20 years most of Britain’s energy system needs to be replaced at an estimated cost of £100 billion.

So it is, but the rewards are potentially high as well. Watt sees big opportunities for large and small companies to make and install domestic wind turbines, heat pumps etc., and that Scottish innovation, manufacturing and innovation could make Scotland a world leader in making “carbon efficient energy production turn from dream to reality”. Fuel cell development should, he thinks, enable the storage of intermittent power from renewables, making them a more reliable part of the energy mix. Allowing the household and community micro-generation that many contributors see as important to flourish will require, notes Wakeford and Marchant, a new local energy grid. Meantime, the National Grid, contends Boulton, will become part of a European energy grid to maximize supplies of energy from low-carbon sources and, says Northcott, to allow Europe to tap into power supplies from Concentrated Solar Power arrays in northern Africa.

I have not attempted to list all the technologies that the contributors think will or may be available between now and 2050. Nor have I delved into the possible new political parties and religions that might be the side-effects of Climate change. And I have resisted cataloguing all the fascinating business opportunities that the writers have cooked up. They are, of course all here, so do go and enjoy them before I return with some concluding thoughts.

Concluding Thoughts

A myriad of ideas, a few really big ones amongst plethora of smaller but equally important ones, have emerged from the splendidly fertile imaginations of the contributors. As Jeremy Peat says, this volume is a treasure trove. There are also some profoundly big themes which emerge about the nature of society in 2050 Scotland. I want to conclude by picking out three, the last one of which is somewhat sobering.

A carbon economising Scotland

If Scotland is to get really serious about combating climate change, it is clear that carbon dioxide does not just have to be taken out of the atmosphere; it has to become a central part of our economy and everyday life. McMillan expresses this in most detail, suggesting that by 2050, everyone will have a personal annual carbon allowance of 2 tonnes of CO₂. This entails entirely new education programmes aimed at ensuring every school-leaver is carbon literate, for just as we now compare prices of goods in shops and things like mobile phone tariffs, so we will have to be able to compare the embedded carbon contents of goods. As we now look at foodstuffs to check their E-numbers and their calorie count, so we may also be checking carbon content. Indeed, by then, consumers will be demanding low-carbon energy-efficient products routinely. It also means that new professional skills such as carbon accountancy and de-carbonising designers/engineers will be in big demand by companies whose success will be measured by how low they can get their greenhouse emissions. McMillan also thinks that these carbon allowances will be tradeable, so people whose lifestyles produce more carbon output will be able to buy unused allowance portions from people whose activities produce very little. This particular aspect may trouble environmentalists, but it will be a feature of a carbon-orientated economy because of the second big theme ...

Empowered Scots

A strong element appearing in most of the papers is that individuals will have much more power over the choices they make in their lives than is the case now. This is already happening through the spread of mobile phones and the internet. And as computing power increases (doubling every two years, according to Moore's Law, with no sign of a limit being reached) so the power of the individual as a consumer making decisions over what to buy and use will also increase. The most graphic example given here is Hazel's vision of how we will be arranging transport. But advanced computing power will transform virtually everything. In only a few years, it has become possible to do all your shopping sitting at home. Now imagine doing, say, the weekly food shopping not just at one online store, but several, comparing all the prices and their embedded carbon content, checking whether items are in stock, and placing orders for, say, half a dozen stores to deliver a total of 50 items to you. All these processes could be carried out in seconds and probably from a device which is mobile phone, film and TV player, radio, music player, etc., which can fit in your hand and be used at the top of mountain if you so wish. It will also give citizens enormous power in the political process. Imagine knowing that an important decision is to be taken by politicians and being able to use your hand-held device to tell them you want them to vote for or against the item. The possibilities are limitless - people will become seriously empowered consumers and citizens. The trick will be making them want to use that power to arrest climate change, because by 2050, we may be living in a ...

A hotter Scotland and nastier world

The impression may have been given in mine and some other contributions that in 2050 we may all be running around doing things differently, but Scotland itself will be much the same, perhaps a bit milder in winter and wetter in summer. That looks unlikely. As the Stern Review said bluntly: "The scientific evidence is now overwhelming: climate change presents very serious global risks, and it demands an urgent global response."

Some of the prospects presented here are truly frightening. Boulton's belief is that rising sea levels, caused by melting polar ice, will have flooded lots of low-lying Scotland, including, thinks Bebbington, the home links of golf at St Andrews. Gemmell considers that people, especially the old and very young, may be living in community domes for protection from floods and heatwaves. Beyond Scotland, but affecting us nonetheless, desertification of large areas of the world, even in Europe, will see millions of climate change refugees on the march. Many of these displaced people, perhaps 500,000 will end up in Scotland. In such a changed world Hanley and others make the strong point that adapting to this change – re-thinking flood management and housing strategies, for example - may well become just as important a strategy as trying to prevent further change.

The prospect of climate change rolling on may also raise a cry of “why bother?” giving succour to the climate change deniers, many of whom may regard any such change as part of a natural cycle rather than anything to do with human activities. Those of us who think we should bother need to have our answers ready.

To my mind, one is that there may well be a natural course of events occurring, but the physics of how adding carbon dioxide, methane, etc to the atmosphere raises temperature is well known and not disputed. So why on earth should we carry on making a bad thing worse?

A second is that although what we do now and in the next couple of decades may not do much to alter trends in the next 50 years, such efforts can have an effect in the next 50 to 100 years and beyond.

A third is that we all want our children, and our children's children to live in a better world and 50 to 100 years time is when many of them will be in the prime of their lives. We have been profligate with the earth's resources, but there is no need for us to make our children's lives worse by carrying on wasting the earth's riches and contributing to turning it into an unpleasant and largely uninhabitable oven. Our children may have much better things to do with what's left of our planet's resources. We need to clear up our mess for their sake.

Peter Jones

Freelance Journalist

Carbon reduction trajectories: the Scottish story

Jan Bebbington

In this essay, I imagine a world where a few countries (Scotland among them) have attained an 80% reduction in their greenhouse gas emissions in 2050 from a baseline of 1990 emissions. Given Scotland's achievement in reaching this target a national representative has been asked to speak at a World Carbon Forum in 2050 to inspire those present, many of which have fallen short of their targets on greenhouse gas emissions reduction. The world in which the speech is being delivered is one where dangerous climate change has been unleashed, albeit that the full impact of this has yet to be experienced. Scotland is, therefore, still going to be subject to global climate change despite its reduction achievements.

Ladies and gentlemen, I am delighted to have been asked to contribute to this virtual gathering to provide an account of how Scotland has, almost uniquely among developed countries, significantly reduced its greenhouse gas emission levels. Our journey has not been an easy one, nor is it any comfort to have attained our goal at a time when world emissions have risen by such an extent that the scientific consensus is that dangerous climate change has started and will accelerate in future years. Despite this, I believe that our own journey has many important lessons for others, who are still seeking to reduce emissions despite our current situation. Indeed, the impetus to reduce emissions becomes more pressing because of the changes that we are starting to experience.

If I had to choose one word that best describes the impetus for our journey to a low carbon¹ economy I would use the term resilience.² The way we achieved our reduction target was to focus on what would make a resilient society that could absorb and adapt to what has become an increasingly turbulent world (both in physical and social terms). While the creation of an economy, ecology and society with greater resilience had many aspects, three components stand out. These are: the role of technology; the importance of individual and collective behaviour change; and changes in culture, values and expectations. I will briefly address each of these areas in turn.

Some of the decarbonisation of Scotland arose from the evolutions and revolutions that took place in technologies used to generate energy, move goods and people around the country, produce food and operate the likes of our water infrastructure. We used new technologies as they became viable and, in many instances, supported research and development to ensure viability was enhanced.³

¹ The term 'carbon' is often used as a shorthand reference to greenhouse gases, of which carbon dioxide is the largest element. Greenhouse gases, however, are often measured in terms of carbon equivalent impacts and hence the shorthand of carbon is often used.

² Resilience refers to the ability to recover from or resist adverse effects of (for example) a setback or disease. An example of conversations about resilience can be found at <http://resilienceblog.blogspot.com/>.

³ For example the support provided to the European Marine Energy Centre test facility on Orkney.

In doing this we backed some ‘losers’, that is, some technology created unintended adverse consequences (with the first generation of biofuel technology being an example) or did not contribute to de-carbonization as much as we had anticipated. The early estimates of the cost curves for greenhouse gas reduction⁴ were helpful, but in the early days we tended to believe the priorities they indicated.

Over time we came to realise that if we waited until all the economic signals and incentives were in place then we would not move fast enough. Given climate change had been described as ‘the greatest market failure’ we have experienced,⁵ we knew that we had to (wherever possible) shape the market to achieve our objectives. For us, given our geography, the longer term ‘winners’ were tidal, solar (once the technology improved in about 2025) and heat pumps. We made many small scale and some large scale technological innovations to achieve our objectives in this area.

Towards the end of our journey we gained more knowledge about what the most powerful next steps were in terms of the physical bits of technology. More importantly, however, we thought about technology very broadly. In particular, we didn’t limit our focus to electricity generation technology, transportation innovations or such like. Rather, we believed that ‘social technologies’ had a huge role to play. This sort of technology encompassed the rules we use to make decisions, the models of thinking that we typically adopted in Government, the taxation approaches we used (with the move in 2017 to a ecological tax base⁶ being a key turning point) as well as how individuals and groups interacted with each other to pursue Scotland’s carbon purpose.

We tried to innovate with regard to decision making in particular, involving wider groups of people in longer and more extensive discussions. This approach also resulted in a sea change of attitudes of the populace towards the political process. Early on we created a virtual parliament that was accessible to all, our political leaders became respected and trusted and we hot-housed them through a series of active ecological, economic, social and cultural think tanks. In short, our democracy became more democratic. This was very effective in helping to develop partnerships that delivered the second and third component of our journey.

At the outset of our journey we knew that technology change alone would not take us to the 80% reduction that we knew was necessary. For example, we had the technology to produce energy from wind but were witnessing high levels of resistance from many communities to have wind clusters or wind farms sited near to them. We also knew that just because it made great economic sense to install further layers of insulation in roof spaces it didn’t mean that people would do it. As a result, a big part of our success is down to individual and collective behaviour change, with collective behaviour change being by far the more important of these two.

⁴ See, for example, “A cost curve for greenhouse gas reduction”, The KcKinsey Quarterly, number 1, 2007.

⁵ See Stern, N. (2006), *The Economics of Climate Change: The Stern Review* (Cambridge University Press: Cambridge).

⁶ A google search on ecological tax reform yields many sources of information. Professor Paul Ekins is one of the UK’s leading writers on this topic, but many other individuals and organizations have considered this topic as well.

Early in 2009 we witnessed a series of movements that came from groups of citizens joining together to support and empower each other in moving towards lower carbon lives. There were many layers of formality to these movements, from the transition movement⁷ to carbon rationing action groups.⁸

These movements were supported by the Government but their activities were not prescribed by Government which resulted in a huge array of social experiments that were and continue to be as diverse as Scotland's people. A focus on low carbon lives, we believe, unleashed creativity on a grand scale (and a step change in resource productivity). This was not new to us as a nation. Scotland has long been the birthplace of ideas that rocked the world. We went back to what we had been good at and adapted it for contemporary challenges.

In addition, all aspects of life were affected. Food was often the focus for thinking about carbon impacts. For example, the now internationally famous 'Fife Diet'⁹ pioneers started a wider movement that spread throughout Scotland. This approach to eating really took off when Rangers and Celtic football teams agreed to eat a 'Glasgow Diet' (of course this diet is now synonymous with healthy, low carbon eating but in the early part of the century this was not the case). Given that world population has reached 9.5 billion, we now eat a largely vegetarian diet, with meat being eaten sparingly, but with great relish. We also started buying products that locked up carbon and supported further carbon reduction in Scotland, for example, by buying hardwood furniture made in Scotland from timber grown in Scotland.¹⁰ We also paid very particular attention to our land use policies to ensure that carbon was sequestered in soils and carbon rich soils were protected from adverse changes that would cause them to release carbon. Likewise, rethinking how to achieve the mobility (without having to own the means by which mobility was achieved) became important and led to car clubs¹¹ flourishing. We also integrated waste and energy policies from the outset.¹² These examples also provide a link to the final element of the Scottish carbon enlightenment, that of the importance of culture in achieving our goals.

In the early part of this century society was driven by culturally embedded values that based self esteem on the level of consumption that an individual could attain. Values in Scotland have evolved since that time so that many individuals' sense of value arises from their relationships with the friends, family and their local, global and virtual communities. While everyone still consumes in order to meet their needs, consumption is seen much more as a means to an end rather than an end in itself.

⁷ See <http://transitiontowns.org/Main/HomePage> for more information. The transition movement is focused on asking the following question: "for all those aspects of life that this community needs in order to sustain itself and thrive, how do we significantly increase resilience (to mitigate the effects of Peak Oil) and drastically reduce carbon emissions (to mitigate the effects of Climate Change)?"

⁸ See <http://www.carbonrationing.org.uk/> for more information.

⁹ More information on the Fife Diet can be found at <http://fifediet.wordpress.com/>.

¹⁰ See Woodschool Ltd in the Scottish Borders for an example of this type of activity – <http://www.woodschoolltd.uk/>.

¹¹ Rather than own a car, car clubs provide a structured way to access motor vehicles on a pay as go basis. For a Scottish example of a car club see <http://www.citycarclub.co.uk/>.

¹² For example, see http://www.sd-commission.org.uk/pages/scot_zero_waste.html.

This was a crucially important element of the transformation and one that was (like many aspects of behaviour change) generated from within the populace. We believe that if one could reliably measure ‘gross domestic happiness’¹³ then Scotland is currently a happier place than it once was, in spite of the global challenges that we are facing.

Of course, while we are proud of our achievements there is no room for complacency for three reasons. First, we did not make this journey alone. Rather, we had the support of many others.

The most significant partnership was between ourselves and India and their infusion of technological and cultural knowledge to us was critical. Second, there was considerable conflict and compromise on the way to achieving greenhouse gas reductions and we lost a proportion of our population to emigration. Of course we also attracted people to us (and, indeed, some Scots are coming home more recently) but we can’t and don’t discount the loss we feel about not being able to take everyone with us. Third, collectively we are living in a time of profound change, given the broader carbon performance of the globe. Like many of your own countries we have had to adapt to more severe winter storms, to more flooding, coastal erosion and also rising sea levels. We limited the effects of some of these impacts by banning building in high risk areas (some 20 years before the actual impacts were felt), progressively investing in strengthening our infrastructure and making a managed retreat from vulnerable coastal locations. This was still a painful experience, especially as we lost many historical sites on coasts (for example, many of you will remember the sorrow at the last British Open played in St Andrews).

Our minds are now turning to how we can play a role in the world going forward and we hope that there are many layers on which we can assist. Perhaps most obviously, we can contribute a wealth of knowledge about how a low carbon economy can be achieved. We have a huge amount of technical know how in low carbon technologies but more importantly we have a broad and deep appreciation of the social and cultural aspects of moving to low carbon living.

At the same time we have a limited, but still significant ability to provide a home to more climate change refugees (having already taken some 580,000 allocated to us by the World Climate Change Migration Programme). We are able to meet much of our need for food in a low carbon manner but still trade with the rest of the world for those things that we cannot grow locally. We are able to heat our homes and move about in low carbon ways as well. Perhaps more importantly, as part of broader social change we have more experience in living with change and accommodating the needs of others when those changes happen. We believe that we are more resilient as a result of this and hence are in as good a shape as anyone can be for what the future may hold.

Like everyone dialing in today, we do not know what lies around the corner as the earth systems go through tipping points. Our best scientific brains are unable to tell ahead of time what new systems equilibriums (or indeed dis-equilibriums) we will be living with. What we do have, however, is an understanding of how the human social systems can evolve to cope with whatever environmental, economic or social shocks arise. We have not got all the answers for all societies at all time.

¹³ An extensive discussion of gross domestic happiness can be found at http://en.wikipedia.org/wiki/Gross_national_happiness.

Our journey worked for us (eventually) but it may not be possible or ideal for everyone: our template for change will need regional and cultural adaptation. What we have, however is the confidence, courage and (here is that word again) resilience to find ways to live, live well and live well with others in this chaotic world we have made for ourselves. In closing, our message to you is that a combination of technological change, behaviour change and cultural adaptation will provide a platform for building a low carbon and hence more sustainable society.

Jan Bebbington

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A tale of misplaced optimism

Geoffrey Boulton

Well, we made it! But in retrospect, there is little sense of achievement, as little of that achievement was due to us, and in any case, our contribution to emissions reduction was insignificant. The global response was too late for the effect we hoped for, and the consequences were devastating. What is now clear is the barrenness of optimism as a policy, both in Scotland and beyond: optimism that the speed and impact of climate change would be low and optimism about the ready availability of technological solutions.

The portents were there to see in the early years of the century. Notwithstanding political jaw-jaw, global carbon emission rates almost doubled between 2000 and 2007. At the same time, the predictions of scientific models that polar regions would warm first and most rapidly were being realised. Dramatic reductions in arctic pack ice cover, permafrost melting resulting in release of methane (a greenhouse gas more powerful than carbon dioxide) were occurring. They were accompanied by acceleration of flow of the ice streams that drain the Greenland ice sheet into the surrounding oceans and the collapse of ice shelves that inhibit such fast flow in Antarctica. The problem was, it was happening faster than the models predicted, suggesting that the more extreme model scenarios might be the more realistic. Impacts closer to home were even being felt in the first decade of the century, although they were not recognised as the thin end of a very large climatic wedge. A tropical disease, Bluetongue, which affects cattle, sheep and other ruminants, had spread like lightning through Europe and into Britain between 2002 and 2008, because two succeeding winters were so warm that the midge vector for the disease did not die off. They were followed in quick succession by BTV 1 and African Horse Sickness. Severe flooding of the east end of Glasgow in 2002, a sign of what was to come later, brought realisation that the Victorian drainage and sewage systems of our cities might no longer be adequate to protect them against ruinous flooding. In retrospect, the increase in mean annual temperature in Scotland of about 1°C in the thirty years after 1970, the concomitant increase of about a month in the growing season, the demise of the Scottish ski industry, the increased frequency of heavy winter rainstorms (occasionally, but unpredictably, a boon to energetic winter skiers), can all now be seen as part of a global trend. From about 1970, the influence of human carbon emissions on atmospheric composition began to dominate climate change above and beyond natural variability, and a warmer world is a wetter world.

The insurance industry realised the significance of these trends. It could no longer continue to assume that past patterns of hazard were a predictor of future patterns in setting premiums, but that it had to use scientific predictions not past statistics as guides: a change that encouraged conservatism and drove up costs. Governments however, though paying lip service, were too preoccupied by the “credit crunch” and the persistent severe structural problems of the global economy to use up their political capital to address in a decisive way an issue that might only begin to affect them seriously several electoral cycles into the future. Nick Stern’s warning, that lack of action now would dramatically increase the cost of taking action in future, was understood, but effectively ignored.

But increasing emissions and climate change carried on regardless. The trends intensified during the succeeding decade. The most severe early impacts were not from increased temperature, but changes in rainfall patterns.

Unfortunately, in the warmer world, the increased energy of transport of equatorial heat towards the polar zones, carrying warm, moist air, missed out the lower middle latitudes, much as the models had predicted, desiccating broad areas of southern Europe, including southern England, whilst increasing rainfall in northern Europe, including Scotland. The most severe impacts, were on the hitherto agricultural fringes of the deserts of North Africa, India, Mid-America and Asia that now themselves suffered desertification. Even more significantly however, the Asian monsoons, the sustainers of Chinese and Indian agricultural production, weakened and became less predictable, leading to decreased food production, massive imports by these powerfully growing economies, with a knock-on, elsewhere, of food shortages, dramatic price hikes, riots and political turbulence. The pressure on both food and particularly water continued to intensify as global population grew inexorably, increasing, as we now know, by 50% from the turn of the century to the present; from about 6 billion to about 9 billion. It was accompanied by a patchwork of increasing wealth and consumption in some economies and impoverishment in others, where deflated expectations were again a cause of conflict.

Scotland, in the early years of the century, had adopted a high risk energy policy, based on the hypothesis that we could increase generation from renewables, initially from proven onshore wind technology and re-development of hydro-power, bolster that by the addition of largely unproven marine generation, and provide vital base load, at least until new non-carbon technologies became available, by continuing to use carbon-based fuels that were de-carbonised by carbon capture and storage (CCS) in depleted offshore hydrocarbon reservoirs or in near shore or terrestrial aquifers. This strategy was encouraged by excessive reliance on presentations by “power-point engineers” and too little on the experience of real engineers, who know that many theoretical options often fail, prove to be too expensive, and where they are tractable, often take much longer to realise than anticipated. CCS was also proving to be elusive. It was prohibitively costly to re-engineer existing power stations to capture carbon, full scale demonstrators were slow to be established, and investment tended to be drawn towards larger economies such as China, where there were greater prospects of major future business. Sadly, there was no “plan B”.

The re-powering of Longannet 1 in 2007 had been a boost to base load capacity, although it did little to help our emissions targets, whilst the no-nuclear policy gave no incentive for investment in the maintenance and improvement of ageing and increasingly unreliable nuclear stations. The result was base load shortage that led to the severe power failures that began in the winter of 2013, even though Scotland was then on target to reach its 2020 goal of 20% of power generation from renewables. The lack of an up-grade in the south-north transmission line capacity from England compounded the problem. In any case, similar failures were beginning to occur in England, although there was a prospect there of new nuclear stations contributing to base load generation by about 2018.

The events however that caused the international community to face reality occurred elsewhere, in Greenland and Antarctica. Fast flowing ice streams in these ice sheets occupy only about 8% of their area, but discharge 85% of their mass into the surrounding oceans. It was known that in the past, accelerated flow in such streams had led to the partial collapse of ice sheets, leading to rapid rises in global sea levels at rates of up to 2m/100 years, and exceptionally 5m/100 years. Although global sea levels had risen only by about 0.2m in the 20th century, largely due to thermal expansion of the warming oceans, only a small amount had been accounted for by surface melting of the ice sheets.

But in the late 1990s, acceleration of Greenland ice streams was observed, possibly induced by drainage of increasing amounts of surface meltwater to the ice sheet bed, reducing basal friction and permitting faster flow. At the same time, and unprecedented since the last Ice Age, we saw the rapid decay of some of the ice shelves in Antarctica (the Larsson B shelf in 2002 and the Wilkins ice shelf in 2008), which are fed by ice streams, which the shelves also buttress against fast flow. Accelerating flow in these streams was observed in early years of the new century. Unfortunately, because of their inaccessibility, our understanding of the physics of basal flow was poor, with the consequence that predictions about future behaviour were difficult. After about 2008, it became clear that the ice streams in the Amundsen Sea embayment in West Antarctica, in the Antarctic Peninsula, in parts of East Antarctica and in west Greenland were reaching sustained high velocities and discharging enormously increased fluxes of icebergs into the ocean. By 2012, it was estimated that, as a consequence, global sea levels were rising at a rate of about 2cm/year, compared with 0.2cm/year in the previous century, sufficient to increase global sea levels by about 2m by the end of the century if fast flow continued. The imminent threats to vast areas of highly populated lowlands became very clear, with the potential demise of the Netherlands, Bangladesh and Kuwait, flooding of large areas of the US Gulf of Mexico, Florida and east coasts, of Myanmar, Thailand and NE China, etc. with massive impact on the populations and economies of most states. Large parts of south eastern England and in Scotland the Forth, Clyde, Moray and Solway lowlands were clearly at risk, with the prospect of major frequent inland flooding along most river valleys. It was no longer in doubt that a major planetary change was under way with enormous consequences for the human population. Past uncertainties about the potential for global change, and whether action was necessary or economically prudent were now unequivocally removed.

The imperative for concerted global action was now irresistible, both for dramatic reductions in greenhouse gas emissions and planning for the protection of populations. The need for developed economies dramatically to reduce their emissions whilst permitting greater emissions in developing economies was clear, but the problem was immense. It would be to replace 10TW (10×10^{13} watts = 10 thousand billion watts; equivalent to 50,000 Longannets) of power by carbon free sources, with an enormous transition of global infrastructure. In Europe, the Commission became the focus for energy planning, resulting in an obvious conclusion that the provision of a pan-European electrical energy distribution system was the best way to ensure that the maximum number of low carbon generation sources could be tapped, irrespective of their location, in an intelligent, largely DC system, that would maximise the prospects of providing supplies across Europe with less transmission loss, and with stringently policed carbon targets. Well-conceived regulation and economic instruments provided powerful incentives for industry to respond to the challenge, which it did with great creativity and surprising speed. By the late 2030s, the new European transmission and supply system was largely in place.

Now, in 2050, flooding of large areas of coastal lowland and of river valleys has become a reality, and together with the other impacts of climate change, has had a massive impact; politically, economically and socially. But although a large part of the necessary transformation of the global energy system has been achieved, and although global emission rates have been dramatically reduced, and atmospheric concentrations have been stabilised at about 550ppm of CO₂ equivalent, (and they now need to be reduced), the Earth's climate and environment are very different from what they were 50 years ago, and future changes, possibly associated with a still warming ocean, remain difficult to predict.

A major present concern is the possibility that the solid form of methane, ubiquitous beneath the Earth's continental shelves, might become unstable because of ocean warming, and add massively to the atmospheric greenhouse effect. Much loss of treasure and life, and conflict, could have been avoided if only the dramatic changes in global energy infrastructure that took place in the 2030s and 40s had taken place 3-4 decades earlier.

Scotland did meet its emission targets set by the Government in the early years of the century, and now it is, for the European energy grid, "the Saudi Arabia of renewable energy", mostly through onshore wind and offshore wind and tide. But that would not have been possible had it not been part of a larger UK and European network. Indeed, reaching those targets is now seen to be irrelevant. The only targets that matter are European and global. Scotland's indigenous science and technology base, and the companies that have exploited it, have been important contributors, and have brought considerable economic benefit to Scotland in difficult times. Its earlier territory-bound policies, as those of many other countries, were clearly misplaced. Cooperation and integration across national boundaries within the framework of an international carbon policy have been the key processes.

Back in 2008, the above is clearly science and technology fiction. But the other contributions to this volume are also technological, economic or political fiction. Is my fiction possible? Yes it is; all the elements in the fiction are possibilities. But how probable is it? Sadly, the system with which it deals is so complex that at the moment we cannot allocate probabilities to particular outcomes. What I have tried to do is to illustrate potential consequences if the optimism that is implicit in many current policies and much public outlook turns out to be unjustified. In the last 100 years or so, the human species has become a major geological agent. We have massively engineered the planet, but out of ignorance. With a population of 6 billion, rising, barring accidents, to 9 billion by 2050, there is no way back to the simple life. We will have to continue engineering the planet, but this time through knowledge and, hopefully, wisdom. Economic theory and practice that regard the planet as "an externality", as if the human economy were a bubble, detached from time and space, need to be changed. Our economic system is not separate from the environment, but part of it.

Geoffrey Boulton

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Climate change target met in Scotland - how did we get there?

Martyn Evans

There were a number of drivers for the eventual success in hitting the targets in Scotland. Behind almost all was the idea that both consumers and citizens were the only effective solution to the challenges and not the problem. Our ability to predict the future was once again found to be laughably wanting, not least among those who foresaw the death of private transport¹.

The transformation took years to achieve and yet when the tide turned the results were swifter and deeper than anyone had predicted. Along the way there were serious mistakes and not a few sacred (as well as real) cows were slaughtered.

Probably the most significant failure was the European wide ‘CarbCard’. Climate change was analysed as “the greatest market failure the world has ever seen”² and carbon trading by individuals was portrayed as an obvious solution. The scheme cost 5 billion euros of consultancy time and the IT system for the CarbCard cost billions more.

The ‘CarbCard Bubble’, as it came to be known, collapsed in acrimony within five years of its launch in 2025. Accusations of fraud, scamming, manipulation, freeloading, speculation and elitism all taking their toll. Many lost their life savings and homes. It destroyed faith in any magic bullet solution.

Before CarbCard there was a general assumption that technology would allow Scotland (and Europe) to de-couple economic growth from polluting energy use. The search for technology proved elusive with many claims that the new dawn was just around the corner but nothing substantive was delivered until the late 2030’s.

Social marketing was popular for quite some time and made some important changes to individual consumer behaviour.

We had government-sponsored advertising campaigns encouraging people to use energy more efficiently, and to reduce waste and cut back on travel. Not surprisingly, these were far from effective at any mass level³, and a succession of environmental targets were set and then quietly dropped as seemingly inexorable trends continued – we continued to travel further, buy more, and demand more growth⁴.

¹ "The real future (of the car) might be sad for us designers. I always say the real futuristic vehicle is no vehicle. In a wireless digi-future, moving is meaningless and expensive for most of the population." **Daniel Simon:Car Designer.2008** VW Group www.cosmic-motors.com

² **Sir Nicholas** Stern, Head of the UK Government Economic Service in the early 2000’s and many others.

³**Social marketing** is the systematic application of marketing along with other concepts and techniques to achieve specific behavioral goals for a social good.

⁴ The eventual passing of the ***Ban on Advertising in Public Places Act 2031*** was a Scottish initiative-followed quickly through the rest of Europe. It was helped enormously by the public view that social marketing came to be seen as ‘smug and insidious’ while commercial marketing was merely ‘insidious’. The ‘*plague of both your houses*’ public *attitude* overcame the dire warnings of economic collapse the advertising industry portrayed in some harrowing advertisements prior to the Act being passed.

The European Parliament had put up a prize of 500,000,000 euros for the invention of a light weight and high power battery⁵. Known as the ‘Harrison Prize’ after the famous 18th century clock maker the results were spectacular. This huge shift in popular culture from consuming to participating⁶ was first seen via the internet and then spread to most forms of human life. Linking incentives to participation opened up massive potential and democratised innovative science.

In fact the prize finally went to a joint venture of a group of Scottish and Scandinavian Universities who had combined with over 100 private inventors and a consortium of former high street banks. This was the last desperate investment throw for the banks crippled and almost extinct by the 2007-15 credit crunch, loss of consumer confidence and the rise of internet banking.

Computing power increased dramatically⁷. Such massive computing ability devastated the legal profession in the rest of Europe.

However the Scottish legal profession had re-organised itself swiftly and with ruthless efficiency following the consumer criticism of its restrictive practices in the early 2000’s. This re-organisation and modernisation of self-regulation allowed it to steal a march on its rivals in the rest of UK and Europe. They led the drive to a low energy and high value economy so sought after by other countries.

Combined with controversial and highly successful reforms to the Scottish civil justice system⁸ it meant that Scotland became the jurisdiction of choice for European, US and Chinese corporations to try to settle their legal disputes.

The job losses sustained by Edinburgh financial services sector due to this phenomenal growth in computer power were replaced by equally well paid jobs in global company and private dispute resolution⁹ services based in Scotland. In addition many former workers in the financial service sector were able to find socially useful jobs using the newly invented super-insulation materials to create warm homes at low cost.

There was a false dawn for some three decades into the 21st century. A combination of the total elimination of the CAP subsidy to all European farmers, plus fresh scares over BSE and scrapes in sheep, rocked consumer confidence in red meat production. Scottish beef production was reduced to almost zero and sheep farming was similarly devastated. The single issue ‘Vegan Party’ was successful at a by-election and then held key seats in the Scottish Parliament. Major reductions in Green House gases were recorded for the period.

⁵ The USA had long had a similar prize as suggested by USA President John **McCain** in his nomination campaign 2008.

⁶ First identified by **John Steely Brown** at the Xerox Palo Alto Research Centre

⁷ By 2020 a laptop computer had the power of a human brain. By 2049 the single laptop had the power all humanity. As predicted by **Richard Susskind’s** *The End of Lawyers?*

⁸ Popularly known as the **Gill Reform Acts** –after Lord Brian Gill.

⁹ The Ewan Malcolm Virtual Mediation Centre in Aberdeen is the largest such centre in the world.

However the powerful Food, Financial and Utilities Standards Agency (FFUSY)¹⁰ was able to claw back consumer confidence in beef production. Sheep farming never really recovered fully and upland re-forestation was started with a vengeance.

Scotland is now self-sufficient in timber – our main construction material now that wooden buildings are the norm – and, as forests mature, is supplying increasingly large proportions of England’s timber too. Mixed use forests provide recreational opportunities, but have also be sited to help reduce the impacts of flooding and storms.

An early example of the new recreational use was the combination of ‘Electro-cycling’ and camping. This became fashionable for weekend activity and also longer holidays all over Europe following the lead of the ‘Easterhouse Riders’. This group of formally unemployed young men and women started electro-cycling for fun on bikes they cobbled together themselves with discarded lithium batteries. They recaptured the spirit of their great grandparents in a longing for learning and the outdoor life. They also saw the commercial possibilities of exploring the new ‘great highland forest’ and glens. They and their ideas formed the basis of the 2150 Party (See below for political developments.)

The thriving Scotland Mutual Building Society had the confidence to invest in this community idea and provided the capital for the first ‘Highland electro-trail’ and campsites (the hills were now a joy to ride up with battery power). The Riders never looked back. It helped enormously that an early Harrison Prize by-product was the elimination of the Highland Midge¹¹ - a loss mourned by only a few diehards in the ‘1750 Party’¹².

Meat forms a very much lower proportion of our diets now, and is entirely free range, and battery farms¹³ were banned in 2019. Gardens and allotments are common in city areas too, providing a social focus as well as local food. Tayside wines don’t yet win many awards, but they are getting better, and the beer and whiskey industries remain very important, focusing on quality rather than quantity.

¹⁰ Created by the merger of the food, financial, energy, post and telecommunication regulators in 2023.

¹¹ The consortium who came up with the invention was apparently trying to find a way to transmit electricity alongside a digital television signal thus eliminating the needs for cabling and massively reducing (to zero they hoped) the loss incurred by resistance as electricity travelled along a wire. They went on to win a Nobel Prize for the elimination of the mosquito in Africa thorough local micro-businesses using their open source invention.

¹² See below for explanation of political realignment.

¹³ Free range units above 1000 chickens were also banned following campaigns by the Peeblesshire based BlythBank Action Group.

The retail market found innovative¹⁴ ways of reducing packaging to almost zero. The self-service revolution was reversed and most large stores (and they remain large) now are split into service units rather like the deli-counters in the old fashioned supermarkets. Shoppers bring their own containers¹⁵. The *re-use* movement overtook the *re-cycle* movement many years ago and was first taken up enthusiastically by low income city-dwellers.

Political re-alignment came as much of a shock to green movement and think-tanks as to the traditional parties. In fact London based think-tanks had had to struggle hard to recover their credibility in Scotland after the Demos *'The Dreaming City: Glasgow 2020'* debacle in 2005. A City of Glasgow spokesperson¹⁶ described the Demos report as, "*Nothing less than an insult to the many Glaswegians who gave up their time to take part. Bizarre would be a charitable way to describe some of the report's conclusions*¹⁷."

In essence the disputed issues were no longer education, health services, crime and defence etc. There was consensus on these matters. The divide between capital and labour which had dominated politics for more than 100 years was not so relevant with mutual banks holding much of the capital and social enterprises the predominant business model.

¹⁴ The Scottish Co-op led the way here and became the largest of the big four retailers after it made an aggressive and successful bid for a larger but slow moving competitor.

¹⁵ Plastic bags were banned in Scotland in 2009 and all plastic containers in 2022.

¹⁶City of Glasgow. Press release. May 2005

¹⁷ Press comments on **'The Dreaming City: Glasgow 2020 and the power of mass imagination.'** By Gerry Hassan et al 2005

"They told us Rab C Nesbitt's wife was called Mary Doll. And apparently, Glasgow used to build a lot of ships, famous ones such as the Queen Mary. Not a lot of people know that.

Demos recommended "assemblies of hope", networks of individuals who could get together to help shape the city's future and find space for everyone from "alchemists to imagineers". **Tom Shields. Sunday Herald. May 2005**

"In the final report, the voice of the people it puts such store by is drowned out by such think-tank claptrap." **Anne Johnson. Herald. May 2005**

The '2150 Party' started in Glasgow¹⁸. It was a combination of West Coast pragmatism, the collective tradition and social inclusiveness. It grew rapidly¹⁹. What had been perceived disadvantages in the past became assets: high density living²⁰, old fashioned mechanical and engineering skills, low car ownership were the bedrock for a political approach, and an economy, based on a vision of 'well-being, fairness and justice'²¹.

The other parties were the '1750 Party' and the '1950 Party'.

The '1750 Party' had its origins in a combination of landowners and 'back to basics' greens. Many members bought smallholdings following the collapse of land prices across Europe. Their major contribution was two fold. They successfully re-connected Scottish agricultural production with consumer preferences and they allowed historians to better understand the social reasons for the 18th and 19th Century '*flight to the towns*'.

The '1950 Party' campaigned for a future of austerity, rationing, politeness and social stability. It had its origins in England and was popular in Edinburgh but never gained much general support in Scotland.

However all three new parties made a major contribution to the shift from the old political alignments. The one thing they all had in common was the desire to create a real understanding that *materialism* and *consumerism* were quite distinct issues.

All the new parties shared a distaste (to greater or lesser extent) for materialism²² but at the same time all three understood that without consumerism²³ the old ways of rampant, anti-social and unsustainable growth led by the producer interest in manufacturing, services and the professions could not be curbed.

¹⁸ Following the European Government reforms in 2032 the role of nation states rapidly diminished and the 'city region' soon became the predominant political unit below the European Government.

¹⁹ The 'C8' group are a club of the most powerful and successful cities in the world. They include Glasgow, Liverpool, Marseilles, Chicago and Lagos.

²⁰ The **Joseph Rountree Foundation** work on 'place' was hugely influential.

²¹ The two main text books for the early 2150 Party members were Mancur Olsen Jr.'s '*The Logic of Collective Action: Public Goods and the Theory of Groups*' and John Rawls '*Theory of Justice*'.

In *A Theory of Justice* Rawls argued for a principled reconciliation of liberty and equality. Central to this effort is an account of the circumstances of justice (inspired by David Hume), and a fair choice situation (closer in spirit to Kant) for parties facing such circumstances, and seeking principles of justice to guide their conduct. http://en.wikipedia.org/wiki/A_Theory_of_Justice.

In *The Logic of Collective Action*, Olsen argued that individuals in any group attempting collective action will have incentives to "free ride" on the efforts of others if the group is working to provide public goods. Individuals will not "free ride" in groups which provide benefits only to active participants. http://en.wikipedia.org/wiki/The_Logic_of_Collective_Action

²² **Materialism** definition: 'a feshistic desire for wealth and material possessions with little or no interest in ethical or spiritual matters' wordnet.dundee.edu

²³ **Consumerism** definition: 'The movement seeking to protect and inform consumers by requiring such practices as honest packaging and advertising, product guarantees, and improved safety standards.' encarta.msn.com/dictionary

The final shift to meeting the targets came when, in 2043, three Scottish Cities contracted with a French city region consortium to deliver a new generation of nuclear power plants. Scotland had scored a major advantage in refusing investment in nuclear plants during the 2020's and early 2030's. The cities could skip a generation in design and fuel-reprocessing and the 'auld alliance' delivered the know-how.

The question most people ask now is: *how come the previous generations were willing to sacrifice so much to keep the right to individual private travel?* The answer probably is that the car was an ordinary family's symbol of freedom²⁴ and independence. It was much more than 'negative'²⁵ travel freedom - it was an expression of unwillingness to be confined to a single place as people had been confined by poverty for generations.

Neither the '1750' nor the '1950' party ever really understood the political importance of freedom to travel. Both were wholly exasperated by both their inability to gain sufficient electoral power and also the way the 2150 Party regularly stole their best ideas.

Old Caravan, C/O Achmelvich Motorcycle Repair Co-op, Sutherland
July 2050

Martyn Evans

Director, Scottish Consumer Council

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As my memory fades over the events of the past 40 years I am grateful to the following for the help given in drafting this short history. However any mistakes and misunderstandings are my responsibility

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- Sarah O'Neill also used to work for the Scottish Consumer Council. She had a distinguished career in public and legal service. She was President of the Vegan Party during its most successful years. She retired recently to live in Las Vegas.
- Anne-Marie Sandison also used to be with the Scottish Consumer Council. She played a pivotal role in helping Scotland achieve its 70 per cent household waste recycling target by 2025. She now co-owns a very successful 'oxygen positive' vegan cocktail bar and restaurant in Las Vegas with Sarah O'Neill.

²⁴ The essay 'Two concepts of liberty' by **Isaiah Berlin** was a key text in understanding the different approach of these new parties to freedom.

²⁵ *Negative liberty is the absence of obstacles, barriers or constraints. One has negative liberty to the extent that actions are available to one in this negative sense. Positive liberty is the possibility of acting — or the fact of acting — in such a way as to take control of one's life and realize one's fundamental purposes. While negative liberty is usually attributed to individual agents, positive liberty is sometimes attributed to collectivities, or to individuals considered primarily as members of given collectivities.'*

<http://plato.stanford.edu/entries/liberty-positive-negative/>

“Climate Change – the view from 2050” –“magnificent pretensions”¹ **Campbell Gemmell**

An old man muses and looks out the notes of a life spent watching the ice melt. ‘91 years old...I never thought I’d live this long! At times it has felt longer’. Adam Smith called David Hume “as approaching as nearly the idea of a perfectly wise and virtuous man, as perhaps the nature of human frailty will admit”⁰. ‘No danger of them saying that about me - far too frail! I look back to summer 2008 and wonder...’

The oil price seeming to peak at \$146 a barrel before we fought over the enormous oil, gas and coal reserves under the Arctic Ocean once the ice had gone and the rigs could move in, the global credit crunch before it really got tight and CO₂ at 387ppm en route to who knows where, but the wrong side of 500.

At that time, these first two, the oil price and the credit crunch, had the attention of the public, politicians and policy makers. After a phase where former Vice President Gore, supplemented by the work of the IGPPC and Sir Nicholas Stern, had managed briefly to get attention for the big Earth picture these more conventional economic shocks came back to the fore. Neither terrorism, nor wars of ideology or resources or bad humoured intolerance and plain low politics nor the challenges of environmental damage or climate change seemed to command media, political or public interest beyond the headline and a short news cycle.

Taking a longer term view and riding and seeing through the short term, especially if it seems to be taking a retrograde step, flowing against the predictions, has always been hard. The visionary leader or advisor can easily be seen as the fool in such a superficial, short term, ignorant (or at least inadequately educated in science and environment), or simply self-interested realm. When the economic going gets tough, the tough get digging and the environment is really just a factor of production, even the air we breathe. Today, the planet is a much sadder place than it was in the “noughties”. Many more species lost, less fresh water except when we have too much or the city water recycling units pack in. Air in our community domes for our core facilities, protected from floods and heatwaves, and where the old folks live with the kiddies, thank goodness. The air that is like the air in the recycled interiors of the old jet aircraft we used to be able to think we could afford as we scurried to see other places that increasingly became like the places we left.

Embracing the challenges, taking the gambles, maximising the flow of benefits over time: that was and remains the trick.

In the year my spark came upon the planet, even Wilson’s white hot technological revolution lay in the future and Chapelcross was launched upon a largely unaware Scotland. That was 1958. 50 years later that nuclear power station is effectively no more - whether the policy makers agree on either side of the border, fission is no more the answer than is oil.

¹ Hume, David (1739/1969 edn) “A treatise on human nature”

Seeing fifty years ahead is a serious challenge and Arthur C. Clark, author of a great deal of future thinking and not long gone from us, said in “Profiles of the Future”² that “any sufficiently advanced technology is indistinguishable from magic”. He also highlighted that humans fail because of “failures of imagination” or “failures of nerve”, or both. We needed magic, imagination and nerve and we still do and some of the technology we have had in the last fifty years is pretty magical stuff. And what the next fifty holds...unimaginable! Fusion alone could do it, once we shake off the hydrocarbon obsession and take our focus on to the infinite rather than the patently finite. And the sun and the moon have a fair bit of fight left – so, solar, wind, wave and tide, plus geothermal and simple thermodynamics plus some prudence and some human ingenuity is really all we need.

And maybe one more thing came to the fore...”loyalty to our single, beautiful and vulnerable Planet Earth”.³

I think it was probably one of the sequence of devastating heat waves in the US North-east and across north-west and central Europe that finally did it, coming on top of the dramatic coastal damage in the 20s after the final decline of the Greenland Ice Sheet triggered the collapse of what was left of the West Antarctic Ice Sheet. That extra 3 metres sea-level rise did the trick.

Catastrophes are great because they allow the incrementalists to say it was all so unexpected. But why is it that we have always had to have the catastrophe before we change, before we take the risk seriously and by then non-polar permanent ice was history. To be fair, even catastrophes don’t always work. I wonder at what we really learned from New Orleans. We used too to worry about ephemeral snow on the putative ski-slopes in Scotland, but Norway and Switzerland losing their glaciers, virtually nothing left in Alaska, the permafrosts melted, CO₂ and methane and chelates released from soil, ice and water bodies and all the infrastructure damage across Russia.....

The drivers were clear and the risk of continued overshoot *very* clear but given the “me now” world, our democratic traditions and the painful models for seeking global agreementand then global oil and global capital, who would lead? To put it another way,

“Climate has always shaped civilization, but not by being benign. The unpredictable whims of the Holocene stressed human societies and forced them either to adapt or perish....The collapses often came as a complete surprise to rulers and elites who believed in...infallibility and espoused rigid ideologies of power.”⁴

Even if it is just the market that is the ideology...are we really paying attention to this supertanker’s direction? Scotland gave the world Adam Smith, David Hume **and** John Muir.

² Clark, Arthur C. (1973) “Profiles of the future”

³ Ward, Barbara and Dubos, Rene (1972) “Only one earth”

⁴ Fagan, Brian (2004) “The Long Summer – How climate changed civilization”

If we are, what is, was and will be the response to the imperative,

“to have a good chance of remaining below 2°C, we will need to halt all greenhouse gases at an equivalent carbon dioxide level of 450ppm”⁴.

I can't help hearing Victor Meldrew, or is it Gordon Brown or Sir Fred Goodwin?

So, what did we do?

We failed globally, in part and we succeeded in Scotland and across Europe, in part. A 50% increase in global population, nearly 10 billion people; new ways of living, many cities of 40 million people, huge challenges in supplying air, water and food...and the same in dealing with our waste, not least human waste itself, especially as the warmer it gets the nastier and more active that waste becomes, although the physics suggest an optimum near 298K; massive food production and consumption challenges and innovations; the redevelopment of almost all the world's infrastructure and dramatic change in new energy options for the planet. The Chinese racing from fireworks through old coal to clean coal to massive solar arrays, on Earth and in space and fusion cooperation with Europe – the joint global torus? The democratisation of the biggest country on Earth in the mid teens was as much a step as the one from Owen and co at New Lanark which London spoiled but in the post-Olympic explosion, it brought the largest, smartest and most active population to bear on the scale of innovation that Seattle and southern California had shown at the end of the 20th century but 50, 100 fold and some good Scots “engineering” went east.

What else happened? More too of what we already had in the first decade of the new millennium. Lifestyle changes (e.g. the decline of the car, more public transport, less 'casual' flights, more videoconferencing, more exercise, less food, more nutri-ceuticals and gene therapies even if they nearly bust banks and systems; more closed systems too, more separation of groups of wealthy and poor and so it went). Energy efficiency was taken seriously and the incentive on companies to buy and sell energy and products was replaced with incentives to provide services and these were traded and then given to those who needed them, much like the AIDS solution when the world realised that fixing the problem was more important than the profit motive and “the costs of not” were just too high. Did we transcend a money economy? Truly?

House clusters were designed along climate friendly principles, with each town and village also having CHP in the centralised/“micro-gen” model world with real centralised post-NIMBY waste management (resource use) world. Even the word waste became a no-no! A kind of “how could anyone be so stupid” swear word kind of a way. The real trigger was not just the oil price and the power cuts and the catastrophes but Senator McKinnon's third round of planning reforms that gave dirigiste a new meaning but drove the housing solutions and the waste management rules that allowed the technologies really to work and be applied. Local resource value-recovery and energy networks became the key component of the energy mix, though they did not replace the energy grids wholly or at least not until the big Russian, Spanish and German fall out over who owned the empty pipes. But the rest of the world watched with interest.

Sensible, sustainable use of heat as well as electricity was a vital component. A combination of taxes, tradable permits, regulation, information and technology got us there (there was no one 'magic bullet'). It was for a while a real tension between the market and regulation. Having seen the first few years of the EU ETS deliver only increased CO₂, some environmentalists saw such mechanisms as great economic sport but with no environmental outcome. So, they said, either we get real and make a 50 euro-plus Carbon tonne the driver and apply caps that pinch and then fall dramatically every 3 years or we scrap the play and take the game seriously. The game itself simply cannot be the thing. When we feel something is very bad, we regulate it and it often stops...but Victorian child labour, canals catching fire and city smogs are one thing, filling up the prisons and stopping the free movement of capital might be seen as quite another. Strange though that punitive financial services fines are viewed so differently from punishing "environmental crimes". One real, the other not?

So, we headed for higher ground and learned to adapt and made sure that we lived 'with the grain' of nature as much as possible, designing win-win solutions for climate change, urban design, transport, flooding, water management etc. We took our great environmental technology and advisory industry, developed in a decade and scaled it with the Chinese just enough to keep the capitalists happy and the environmentalists no more miserable and "hair shirt" than usual!

For the landscape it was dramatic. In a lower quantity and more expensive protein world, post-old agriculture, if not kangaroos, then certainly not cows and sheep. And intensive went out way back, the deer and the trees filled the countryside. The Earth Food movement brought health benefits and lowered the local and the global footprint, even helping us win more in sport! Diffuse pollution disappeared, really! And Scottish beaches became joys to behold either side of the monsoon summers when the really warm weather dominated February to May and October to the solstice. The hurricane season did become a pain, however.

Back to Brian Fagan, he points out that "agriculture is less visible to us now, the number of people growing food has shrunk from 90% of the labour force in Europe five hundred years ago...but we still need to eat." I bet it has grown from the 1.5% nadir to nearly 40% today and this 2050 world makes most of the physically active population cultivators of their food to varying degrees.

Agriculture's climate impacts have been many, the main sources were always carbon losses associated with clearance and soil management; N₂O from fertiliser application, methane from animal husbandry and manures. We were just starting to assess how agriculture affects climate change back in 2008. What we needed were better land management practices; paying farmers to be 'carbon stewards'; improved, modern land and buildings; better management of fertiliser and alternative applications to land; exploiting the potential for bioenergy and bio-gas (from manures, wastes etc.). We saw reports suggesting 18-25% savings by 2020 after which it would then start to get tough - reducing animal stocking densities and absolute numbers; technological interventions to improve enteric processes; genetic engineering of crops...but that was all overtaken by the crop wash-outs and burn-ups and animal losses through droughts and heatwaves and we just had to move on. Sometimes the frog gets boiled!

We even played, and again I thank the economists (Will wanted to do for the lawyers, me, it's the economists!), with managing futures prices and hedges, oil price error bars, the success of offshore versus onshore wind (it had to be offshore given the potential), all the renewables versus indulgences (only the rich could afford it) and clean coal plants with a plumbers nightmare. Carbon capture and storage they called it. Pump it into the ground they said. No-one'll notice, they said! It's our North Sea; we'll wait for the bubbles, we said. And who's to pay, we said. Ah well, just prepare, they said. And still they only converted 40% of the energy out of the coal. Leave it in the ground, we said. And so it was....eventually.

In the end however, I always was with Walker and King ⁵, “This is neither the time to panic nor the time to bury your head in the sand. It's the time for action.” Thank goodness, we did!

Campbell Gemmell
Chief Executive, SEPA

This paper very definitely represents only the thoughts of Campbell Gemmell, who happens to be the CEO of SEPA when not writing this. I have benefitted hugely from work done by SEPA colleagues - Mark Aitken, Peter Finnie, Dave Gorman, June Graham, Peter Singleton and countless others. I also have digested and learned from SEPA's GRIP tool and the Scotland's Energy Scenarios work done by Caroline Francois, of which I hope much more later.

⁵ Walker, Gabrielle and King, Sir David (2008) “The Hot Topic – How to tackle global warming and still keep the lights on”

‘It is 2050 and the government’s climate change targets have been met – how did we do it and what does this brave new world look like?’

Nick Hanley

This paper is a comment on how Scotland might best chose to meet the targets it has set itself on climate change, viewed from the perspective of how an economist might look back from 2050. I do not have much to say about “what this brave new world looks like”, but focus instead on “how I wish we had done it”.

The Scottish Government’s Climate Change Bill consultation (SG, 2008) sets out an ambitious target: that net emissions of Green House Gases (GHGs) from Scotland should fall by 80% compared with 1990 levels by 2050¹. This exceeds the UK government target of 60%, and would imply a fall in CO₂ emissions from around 13.5 million tonnes carbon (mtc) per year to about 2.7mtc² (Scottish Executive, 2007). Put another way, this would imply Scotland achieving a per capita emission rate which is as low as the current average for developing countries, at around 0.5 tC/person/year, from the current 2.3 tC/person/year in Scotland (Markandya and Halsnaes, 2004). That is a massive change in behaviour by any standards. Whilst 2050 is a long way ahead, a brief glance at long-run historical energy use figures reveals the scale of the challenge (eg Warde, 2008). Looking back from 2050 then, we would see that the behaviour of households and firms in their use of energy had changed to a very considerable degree, and that the implicit real price of GHG emissions – the “carbon price” - had increased by a very large amount.

A related point is that, even if Scotland has achieved its 80% target by 2050, this will have made a vanishingly small contribution to global CO₂ or GHG levels. Currently, Scotland’s emissions account for 0.15% of global GHG emissions, and this fraction will fall as emissions from countries such as China and India rise. However, the argument is that Scotland must be seen to “do its bit” and even “take a lead”, whilst the UK government and the EU are both bound by Kyoto targets, and will both be party to targets set in any post-Kyoto agreement. Indeed, both the UK and the EU have their own “domestic” targets for CO₂, which can be expected to get tougher as time goes by *assuming continued domestic political support for reductions in GHGs*.

As I argued in an earlier paper (Hanley, 2007), adaptation should also be part of a Scottish climate change strategy, since this makes economic sense for a small country. Moreover, it is hard to find any justification for what makes 80% an appropriate target for Scotland. But if we have arrived in 2050 and achieved the target, there is not much to be gained from wondering “was that wise?”, or “how much better off could we be today if we had set a different target?”

However, for the purposes of the current “thought experiment”, let us accept the target of an 80% reduction in emissions from Scotland, and consider how this might best be achieved. Looking back from 2050, the economist would want to see that politicians in Scotland, the UK and the world community had adhered to the following principles in deciding *how* to attain their climate change policy targets.

¹ There is some uncertainty over whether all GHGs will be included in the target.

² Note that these figures relate to tonnes of carbon, whilst those quoted by Peter Jones are tonnes of carbon dioxide equivalent.

1. Get the prices right

A focus of the Stern review on the economics of climate change is the price of carbon. As argued elsewhere (eg Nordhaus, 2007), setting a *global* price of CO₂ which reflects targets for reducing concentrations has many attractions as a way of efficiently reducing emissions from all sources. Prices have a direct influence on the behaviour of firms and consumers, as may be seen from responses to recent increases in world oil prices. A carbon price reverberates around the economy, and forces everyone to consider the impacts of any action that uses energy. It encourages use of low-carbon energy sources and transport modes, and discourages use of high-carbon sources. It incentivises research and uptake of low-carbon technologies. Establishing a price for pollution is central to the use of market mechanisms for pollution control, which we can expect to reduce the overall burden to the economy of achieving climate change targets. However, as evidenced by recent political responses to the fuel duty escalator in a world of rising oil prices, carbon taxes would be a hard sell. Moreover, the Scottish Government's ability to enforce its own carbon tax is very limited.

A price of carbon does, however, exist: the price of emission certificates on the EU's Emissions Trading Scheme. As the Consultation makes clear, any Scottish climate change strategy has to "fit in" with the operation of the EU-ETS, and with its expansion in scope in the future. Currently, the price of phase 2 permits is around 25 euro/tonne. Some commentators feel that EU-ETS prices have typically been "too low", given the generous initial allocation of permits, and the role of flexible Kyoto mechanism credits in pushing down prices. But at least the scheme has established the principle that the right to emit greenhouse gases is something that should be paid for (at least by some sectors of the economy). One useful role the Scottish Government could play is in arguing for (i) an extension of the EU-ETS scheme to other emitting sectors (ii) the ability of land use managers to act as suppliers of carbon credits and (iii) a reduction in the total supply of permits. Increasing the reach of the implicit pricing of carbon via the EU-ETS will mimic at least some of advantages that Nordhaus and Stern show exists for a "pure" carbon tax.

However, it is not just a sufficiently-high price for carbon that needs to be established. Prices need to be established for all externalities. A price on methane and N₂O would encourage farmers to change their practices to reduce non-point source emissions of these GHGs, since they would now be rewarded financially for doing so. A price on methane would help incentivise waste producers to reduce disposal to landfill sites, and would reward schemes which recover methane. A price on congestion would divert some car drivers onto public transport or their bicycles. Finally, putting a price on landscape and wildlife would mean that the externalities of wind farms and new transmission lines were incorporated into economic appraisals of new renewable energy schemes.

2. Encourage new technologies

The costs to the Scottish economy of reducing GHG emissions depend partly on what low-carbon alternatives are available for satisfying energy demand. This is most obviously true in electricity production, but is valid throughout the economy. Whilst market forces can be relied on to produce incentives for firms to invest in new technologies which are likely to be profitable, R&D produces public good benefits which mean that there is a role for government in incentivising R&D and the uptake of new technologies, for example through the tax system, via subsidies for clean technology up-take, through funding blue-sky research and through spreading knowledge.

Government actions in setting carbon taxes, or establishing targets for renewable energy delivery will also have effects on the nature and speed of low-carbon R&D. However, governments are not best-placed to guess technological winners, and thus should avoid policies which involve having to make judgements on which technologies to support. Moreover, we also know that relying on technical improvements in energy efficiency to reduce energy demand and CO₂ emissions is unwise, since “rebound” effects can result throughout the economy from improvements in energy efficiency which act to drive energy use and emissions upwards (Allen et al, 2007).

3. Avoid over-regulation

The Scottish Government, in their consultation paper, suggest that various subsidiary targets could be part of the overall target for reducing CO₂. These include:

- A target for renewable electricity production (31% by 2011 and 50% by 2020); and
- A target for energy efficiency improvements (not stated)

But does it make sense to impose such restrictions on the overall 80% cut target? Economic intuition would suggest that the answer is NO. Why? Because setting sub-targets such as those above reduces the flexibility with which the overall target can be met, and thus increases the costs to the economy of meeting the overall target. It also assumes that the government can calculate the most desirable (lowest overall cost) way of meeting the target is; implicitly, the government is saying that this will involve at least 50% of electricity being met from renewable sources by 2020. But what evidence is this based on? My earlier paper showed that renewable energy investments were actually a relatively costly way of reducing CO₂ emissions in Scotland, as the Table below shows:

<i>Sector</i>	<i>Costs per tonne CO₂ reduced.</i>	<i>Comments</i>
Industry	£19	Current EU ETS price.
Housing	£negative	Based on UK wide data
Transport	Not known	No Scottish research available
Renewables	£11 - £49	Depends on whether on- or off-shore wind and whether replaces coal or gas
Agriculture	£10	Can deliver up to 1 Mt/yr., but based on US/EU data
Forestry	£4-£12	Assumes additionality

Much better for the Scottish Government to set the overall target, establish a menu of economic incentives which encourages this to be achieved, and then let firms and households decide on their own best responses. Note that such a “menu of economic incentives” would include the EU-ETS price, a methane reduction incentive, and a subsidy for carbon sequestration from land use. And much better to allow a range of carbon and GHG-prices to reverberate around the economy, and encourage R&D, than to proscribe uniform cuts in emissions, or improvements in energy efficiency, across industry, the service sector, the public sector and households.

4. Remember adaptation as a strategy

The world is already committed to future warming and climate change, irrespective of what happens to global emissions. That much is clear from the most recent IPCC reports (IPCC, 2007). Scotland will therefore experience the effects of climate change whatever it decides to do about emissions. This means that adaptation – actions to reduce the Scottish costs of future climate change impacts – makes a great deal of economic sense, so long as the costs of adaptation are less than the benefits (avoided expected damages). This might involve a re-think of flood management and housing strategies, changes in biodiversity management plans, and investments in health care. Finally, some sectors of the economy might benefit from climate change – agriculture being one example.

5. Choose the right way of expressing the target

As the Consultation points out, setting the target in terms of cumulative emissions rather than end-points, or requiring certain interim objectives to be met, are both likely to increase the costs to Scotland of reducing emissions by 80% by 2050. If interim targets are to be set (perhaps because of political imperatives), then from an economic point of view it makes sense to start with modest objectives which can be taken up by many sectors of the economy, then gradually wind up to deeper cuts. This time profile has two advantages: it allows for the depreciation of current carbon-intensive capital stocks, and for technological progress in low-carbon alternatives to reduce the cost of “de-carbonising” the economy.

So would The Economist in 2050 be able to conclude that the politicians had followed these principles?

Clearly, the answer I hope would be “yes”, and we certainly have seen an increase in the knowledge of and enthusiasm for economic instruments as a tool of environmental policy in the last 10 years. However, my bet is that our mythical 2050 economist would only be able to award a less-than maximum score to the Government. Climate policy is too much of a political football at present for rational thought to prevail.

Nick Hanley

Professor of Environmental Economics, University of Stirling.

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‘Mr Presiding Officer’? ‘An Old MSP Reports’?

Patrick Harvie

The trend toward target-driven public policy has grown enormously in recent years, and has attracted legitimate criticism at times. A balanced view, I think, is to recognise that this approach has chalked up some genuine successes and some very clear failures. Some institutions which have found themselves too focused on meeting multiple targets have sometimes lost sight of wider issues, at the expense of the people they serve.

Ever since the first proposal to set greenhouse gas emission targets as far ahead as 2050, and to make them the principle mechanism by which government addresses the startlingly urgent problem of climate change, it has been clear that anticipating what might go wrong will be difficult. Only with hindsight do novel policy initiatives ever look like sure-fire successes or inevitable flops. But with climate change, we simply cannot afford to fail. Even hitting the targets does not assure the future of our society, our economy, even our civilisation itself. Severe damage to our ecology is unavoidable. But failure to achieve these reductions would make the threat insurmountable.

It is with these thoughts in mind that I anticipate my job, along with fellow members of the Transport, Infrastructure and Climate Change Committee and other MSPs, of scrutinising and hopefully improving the Scottish Climate Change Bill. It is also in this frame of mind that I was intrigued by the invitation to contribute an article looking back from the vantage point of the year 2050 itself. All being well, I will be approaching 80 years old by then and if I haven't retired I will be very ready for it. I have no idea whether I will have the opportunity or the inclination to spend so long in politics, but it struck me as an interesting project to write the article as my retirement speech. Which is why I'm spending part of my summer holiday on the beach in Brighton tapping away and wondering what tack to take. How optimistic should I be? Will our effort end in dismal failure, or will we be just one of the 'early entrant' nations in a great global transformation to a sustainable world, resilient to the effects of climate change and contributing no more to the problem?

I hope that my effort to answer these questions is worth the reading. May I ask one small favour before I begin; if I get it embarrassingly wrong, please don't show me this text again in late 2049. Just let me sidle off and enjoy my retirement with a tiny bit of dignity.

Scottish Parliament

Thursday 17 March 2050

15:10

Patrick Harvie (Glasgow) (Green):

Thank you Presiding Officer, and on this occasion may I also offer my thanks to the many people over the years who have helped to make my time in political life an enjoyable, and I hope an occasionally useful one. When I first entered this Parliament... not this Chamber of course, we've been through enough of those in the last few decades I think...

Members: a few too many!

Patrick Harvie:

Indeed. When I was elected, to put it that way, there had been just one lone Green voice before me, the man with the scarf, Robin Harper. Now look at you all! You and I know that without the efforts of many unsung heroes who make our work possible, we would be nothing. Our work over the years has been built on theirs, and I would like to begin by thanking them.

But looking at you now, especially as we debate the Scottish Government's climate change targets and the efforts, such as they have been, of successive governments in attempting to meet them over the last forty one years, I cannot help being nostalgic. Because in the first few years of my own career as an MSP, I found myself with the job of convening the committee which would scrutinise a Bill to give Ministers the duties against which we now hold them to account.

Over the years we have seen the Ministers come and go. The first to have climate change made explicit in his job title was... Steven... er... Steven Stewartson. He assured Parliament that the Bill would make Scotland a world leader in the field of climate policy, and that was a fine sentiment. We know now of course that much of the transport infrastructure he approved was quite incompatible with the sustainable transport system we now enjoy, and we can only guess at the saving both of money and of greenhouse gases which could have been made had his government taken a different approach.

But progress takes time, of course. Each generation recognises the faults of the last one, and cannot comprehend the folly. It is now a matter of record for example that vast sums were spent on building more aviation capacity which was later dug up for cabbages as people finally came to accept the End of Oil, and the drivers who today whizz silently over the Forth must wonder to themselves whoever thought that seven such *iconic*...

Members:

laughter

Patrick Harvie:

...seven such iconic road bridges were needed for the few commuters who still spurn the excellent service which runs on the Alex Salmond Memorial tram line.

As for energy, it is today easy to forget how close we came to making precisely the same mistakes. If we had followed the lead of our neighbours across Europe and regressed to nuclear power, we would have spent the late 2020s enduring the ills of Peak Uranium with them. As it was we were spared, and the public investment in wind, marine, microrenewables and demand-reduction which took place in the previous decade proved to have been a wiser investment than we could have guessed. A renewable contribution to baseload, combined with a slashing of demand on the grid, gave the Scottish economy the edge it needed, and as a result the fixed price electricity contracts secured with our European neighbours paid for the world's first major DC grid connection, demonstrating the technology which has since spread as far as the North African solar fields.

Our focus on the future remains as strong today, and we keenly anticipate the first generation of artificial photosynthesis devices coming onto the market later this year, which will lead to a proliferation of micro-ambient energy harvesting in every home, office, factory and farm.

Sadly of course, these achievements came too late to prevent the harm we have witnessed. There have always been those who looked too single mindedly at the targets themselves, rather than at the nature and pace of change. So initially our achievements fell short of our ambition, and with our heavy reliance on coal Scotland's emissions continued to increase throughout the first ten years of the project. We also came to the realisation that the targets themselves were insufficient, and we mired ourselves in endless debates over whether to raise them in line with the science, or to strive harder to meet the existing ones.

Eventually, the realisation dawned that fundamental change was required, and voters saw the brutal effects of climate change throughout the world for themselves. The science had been undeniable for years, but suddenly so were the daily news reports of death and devastation. People began to accept that only a fundamental change of values could achieve what government targets had failed to achieve, and they began not only to vote for those values, but increasingly to live by them. Tragically the early failures meant that despite the major cuts made in the 30s and 40s, our cumulative emissions have still made Scotland a major contributor to climate change in global terms. Though our emissions now are scarcely above the global average, we still bear the responsibility for our late action and for the harm this has caused and will continue to cause for decades to come. This responsibility is one of the reasons why we, along with the other nations in the Social Union of the Islands, find ourselves offering refuge to hundreds of thousands of new climate migrants from countries worst hit by flooding, crop failure, economic collapse and the spread of disease. The benefit to us, as I have always felt was one of the silver linings to the cloud of forced migration, is that they can teach most of us a thing or two about cooking. Glasgow had its first Kurdish restaurant in the early 2000s, the result of a different kind of migration, but our food culture today can only be described as post-fusion. As the old United States of America began to contract to its inland core, and the abandoned millions from the coastal cities sought refuge in Europe, we lucky Glaswegians discovered what magical effects take place when stovies meet the creole tradition.

Of course the latest generations of New Scots didn't have it easy. Like those who had failed to take up the public investment in renewables, like those who remained dependent on once-giant retail chains instead of jumping early onto the allotment bandwagon, and most of all like those who jealously guarded their place on the property ladder until it fell from under them, they found adjustment to their new circumstances challenging. But freed from the relentless pressure to acquire and flaunt material wealth, and to judge one another by their acquisitions, our society has managed that inequality rather better, and reduced it more quickly, than was the case with the poverty of the post-industrial society we left behind.

Presiding Officer... I should say Presiding Officer and friends... all right, friends and others, I have been here quite long enough, as I'm sure some of you will agree. I certainly feel it. Tomorrow I reach 77 years of age, and a few days after that you will all race off to your multi-member wards and try to persuade the electorate to send you back here. I hope the weather holds fine. I also hope that all of you, across the political spectrum, will ensure that the policies you pursue – and the political philosophy which underlies them – will also give me hope that the climate will hold fine, not just for this year, the year of the historic target, but for the decades, for the generations, indeed for the centuries to come. You can, you know. You can implement your policies at home, you can work with your colleagues throughout the Social Union, you can help to shape the approach of the Federal Government in Brussels, and you can send your ambassadors throughout the world to build on the work we began all those years ago.

We had the task of beginning a transformation. You have the task – perhaps an even more challenging one – of making the achievements to date irreversible. A climate change programme can't just last forty one years; it's forever. The reversal of what has been achieved must become as politically unthinkable as the reversal of the abolition of slavery, or the reversal of universal suffrage. The only way for human societies to exist, from this year onward, is in balance with the world which sustains us, and with compassion for all who share it with us. This, rather than the relentless pursuit of everlasting growth from finite resources, is the new political and philosophical basis of our culture, and it's a damn sight more humane to live in than what went before.

I move,

That the Parliament recognises the tireless efforts made over four decades to work toward the target of reducing greenhouse gas emissions by 95% from 2009 to the present day; congratulates the entire nation and successive generations of Scots for achieving the target, but deeply regrets that rapid progress took place too late to ensure that Scotland's cumulative emissions were cut sufficiently; therefore accepts responsibility for Scotland's excessive emissions since the target was set, and for the unknowable deaths and suffering which this has caused; recommits itself to embedding low-carbon living and sustainable consumption patterns into every element of public policy; believes that the conspicuous greed, which characterised society over much of the last century and which is inextricably linked to ecological harm of all kinds, must never return to demean and diminish human society; approves the Scottish Government's new strategy, *Global Ecological Transformation; Scotland's contribution*.

15:21

Presiding Officer: We come now to Decision Time.

Well that will be then, and this is now. I should add a small caveat. Though I am convinced that reducing both our greenhouse gas emissions and our depletion of non-renewable resources can be done in a way which brings not only survival but incalculable benefits to human existence, I can't be confident of our success. Not to try is of course the best of guaranteeing failure. However our greatest efforts will not in themselves guarantee success. We face unprecedented challenges to the survival of our civilisation in the coming years and decades, and cutting our greenhouse gas emissions is just one of the things we must do if we're to give ourselves a fighting chance. It may be that we are already too late to begin the task. It is certain that whatever any Minister of any political stripe will tell you, no government on the planet has yet begun to tackle the issue in a consistent and urgent way. In democratic terms, it remains to be seen whether any politician who tells the frightening news honestly will be able to remain in office long enough to do anything about it.

In short, I am hopeful, but not optimistic.

Patrick Harvie MSP

Convenor of the Climate Change Committee

**Transport 2050:
A New Mobility Paradigm**
George Hazel¹
Steve Cassidy²

Brief to Authors

to consider themselves in 2050, with the Government's target for emission reduction achieved, and to set out how this was done and what the impacts were.

Introduction

The external costs of transport to the UK in the late 20th Century are well known. The costs of congestion were estimated at £15 billion pa, there were over 3,000 deaths pa and the sector contributed to 28% of the country's CO₂ emissions³. In the run up to 2050 there were a number of events which intensified these externalities and paradoxically led to the achievement of the Government's targets for reductions in CO₂ emissions by 2050 established in the early 21st century.

Writing in 2050 it is worth examining how this happened, describing the new mobility paradigm which has emerged and giving examples of how mobility is continuing to be a lead sector in greenhouse gas reduction. In the early 21st century a range of scenarios were predicted for 2050. These described distinct futures where certain trends and issues were more dominant in shaping the urban and rural fabric of our society. Typical were those contained in the UK Government's Foresight Project: *Intelligent Infrastructure Futures*, which depicted four scenarios for 2055. These scenarios were:

- Good Intentions: legislation and public opinion moving in harmony to reduce emissions;
- Perpetual Motion: technology providing most of the answers;
- Tribal Trading: sharp and savage energy crises coupled with a lack of progress in technology, leading to widespread return to small self sustaining colonies⁴;
- Urban Colonies: high density cities are the focus of most human activity and the car has been proven to be unsustainable – travel in cities is only highly green and clean.

Each scenario described at the beginning of the 21st century contained some accurate aspects of prediction of the then future. However, many factors have come together to produce the mobility system we now have. The main aspects of this new system are described below, followed by the triggers and influences which have led to its realization.

Transport 2050: The New Paradigm in Mobility

In 2050 we now have a mobility system which is sustainable, flexible and capable of being proactively managed to play its full part in achieving the Government's targets.

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³ Royal Academy of Engineering, Transport 2050 March 2005.

⁴ Witnessing travellers even reverting to horse born travel.

The central concept is that we can base the system on choice and incentives – a carrot/carrot approach rather than the traditional carrot/stock; this is delivered through the “personal mobility planner”, a device developed from the PDAs of the early 21st century, and its links to databases containing details of every form of available transport in every corner of the planet. So, if today, we want to travel from Edinburgh city centre to Novosibirsk or North Berwick, our PMP will tell us what trains, planes, airships, buses, bicycles, electric cars, etc we can use to get there and how much the journey will cost by each means both in money and carbon units. We know that if we sue a low carbon output route, we will get mobility points on our mobility smartcard wchih we can use for other travel purposes.

There are three particular strands to this new “complete mobility” system.

End User Focused

The mobility infrastructure and service offering is focused completely around end-user requirements. This view now pervades all thinking. There has been a paradigm shift from passive administration of infrastructure to active management of services with the user at the centre. The main aspects of this end user focus are:

Personalized mobility: With a long standing trend to individualism building from the 1980’s, consumers were seeking more opportunities to customize and personalize goods and services. While this applied to all services, including mobility, the growth in new mobile media facilitated this tailoring (especially in information and payment) to take place. At the same time, people’s lifestyles became increasingly complex, and their needs and wants less predictable, with increases in sub-urbanization, single parent households and more part time working⁵. As such there was an opportunity to match this demand for personalization with targeting of services – simplifying the complexity of options to users.

Options: Given the complexity of services being provided, travelers in 2050 are now presented with a range of mobility options which intimately reflect their needs and wants. These needs and wants may be expressed in terms other than transport and mobility and may not be presented direct to the user. Thus users now express their mobility needs in terms of their environmental impact or by trip-chain multi-purposes. They may also express them via third parties (eg via travel advisers, employers or health professionals (for health related trips)).

For example, travelers now choose from a range of mobility packages. These packages offer best value pre/post payment for private transport (eg parking, road use, road tax, car share), active transport (eg bike hire, maintenance) and public transport (eg taxi, dial-a-ride, business commuter bus). The nearest example in 2008 was the mobile phone packages, tailoring sms and air time and on-line service packages to certain target audiences.

These packages can incorporate personal lifestyle preferences such as comfort or wider social values (e.g. environmental consciousness) as well as qualitative and quantitative economic priorities. Importantly these packages provide a clear contract between operators and the user and are linked to mobility points which can be cashed in at rates which reflect current policy and personal priorities. Thus, 100 personal mobility points may be used for city centre parking for Christmas shopping, while utilizing park and ride at the same time would actually credit points.

⁵ Which, amongst other things, has led to an increased emphasis on non-radial, off-peak travel, met by demand responsive transport (both as a main mode and as a feeder service to mass transit).

In 2050 people are proud of the type of package to which they are subscribed and the level of membership they hold. The contribution of the employer to personal mobility packages is an important part of work contract negotiations.

Information and Communication Technology (ICT): ICT is now at the heart of the user experience. There is a trend to networked living where consumers are increasingly willing and able to use connective technology to help manage their lifestyles. ICT plays a key enabling role in presenting static, real time and predictive mobility information and impact information, as well as network control capabilities. This is built upon the accurate and reliable collection and collation of data, which is disseminated as reliable information. It also facilitates seamless mobility via smart, personalized ticketing. Importantly, ICT has played a key role in making environmental targets real: the public knows how well their area, city, region, country is performing via the monitoring, reporting and dissemination infrastructure which is available. The public knows when more action is needed and accepts that prices and charges and access to the mobility network will vary to ensure targets are achieved.

Informed decisions: The user is now able to make informed decisions regarding the options available. Importantly these include the full range of choice factors (journey time, cost, comfort, wait time etc) as well as new choice parameters introduced as part of local policies (e.g. environmental impact). Choices are now transparent to the traveler, as well the impacts of these choices.

Personal Connectivity: Multi-tasking on-the-go is now the expectation in today's complex lifestyles. The system and services have successfully exploited this trend. Options for connectivity are provided during travel and new connectivity channels are exploited for mobility delivery (eg offerings of targeted incentives via social networking sites).

Mode Neutral: The range of modal and virtual options on offer, and the tools to make informed decisions built around mobility choices, means that modal emphasis and choice is now a thing of the past – you take the mobility package which best suits your needs and spending priorities: information, tailored packages, price, journey time and other choice parameters come together to suggest limited optimal personal trip choices. The traveler does not feel coerced and the user feels supported in their lifestyle decisions. A non-car owner may often drive a car club car; a regular car driver may often use a taxi and bus. The “public/private transport user” dichotomy is no longer talked about. The system recognizes that the journeys people make are a mixture of modes; transport silos have gone.

Seamless

Physical, financial, and service provider/operator exchanges within a journey are now imperceptible to the user.

Physical and Virtual Integration: When a modal transfer, or a change in sub-mode is required, it takes place at interchanges which are physically proximate. The user is presented with a virtually integrated system, meaning that information provision facilitates easy interchange. Virtual integration can also refer to the provision of on-line services which lead to physical trip substitution (eg online government services, home working).

Important in the achievement of seamless travel has been the development of mobility centres. These are not only physical interchanges between transport modes and services, but also places where information transfer and activities take place (eg mobility centres located on new residential developments where community facilities, child care and cafes are located within these hubs). In fact many travelers do not even perceive these centres as “mobility centres” – they are seen as natural activity/lifestyle points, which happen to provide personal travel information and high connectivity.

“Zero-Wait State”: The whole system is driven by the vision of a “zero-wait state”. A “zero-wait” state objective minimizes the delay to the user before, during and after a journey, pre-journey planning and information facilitates the journey or virtual connection, integration and co-ordination ensures the achievement of a zero-wait state at transfers, management systems minimize delay across all modes during travel and coordinated and reliable arrivals minimize wait at the trip end.

Valued

This means that the user perceives value from engaging with the mobility system. We have known for a long time that public sector funding alone will not be able to fund the transport systems required for 2050. The private sector and users have to contribute as well. It is also accepted that in 2050 in order to influence transport behaviour a transport system must be developed which is highly valued by the user. The transport system must demonstrate value to users. Therefore in 2050 the mobility system presents choices which allow tradeoffs and gives feedback on the performance of these choices. It provides a system which is high quality, reliable and flexible throughout the day and night. It demonstrates value to users.

Trusted Services: Mobility services and information are now achieving very high approval and trust ratings from travelers. Service providers are perceived as trusted partners who support lifestyles. As noted above (Options) users may obtain information from third parties. It is thus important that the system provides timely and accurate information and options to these third parties. This relationship requires accreditation of third party information providers, be they specialist travel advisers or advisers linked to certain destinations (eg hospital travel co-ordinators or workplace travel co-ordinators).

Perceived Value: Users now perceive value in the mobility services and mobility information they use. This is strongly related to the next attribute.

Make a Difference: Decision making by the user consistently obtains the desired effect. Moreover, feedback from the system ensures that the user understands the efficacy of their choices. This is a golden thread running through the 2050 mobility system: without feedback users will not perceive the full value of their choices, will not have any desire to act on information provided and will not be willing to pay for personalised information⁶. Thus, travelers receive feedback on the performance of their trip. If they were given en-route information to change sub-mode, route, or even to abandon their trip, travelers will receive a post-trip report on how much time/money/CO2 this saved them. If the information was not of value, credits to their mobility package will be applied.

⁶ The role of traveller sensors, collation and mining/modeling of data generated, integration of data, and communication of resulting information is essential to this.

Transparent Value Proposition: The user will clearly understand the total benefits and total costs of using the mobility system. The benefits will outweigh the costs, reflected in the perceived value.

Payment Mechanism: A flexible and simple to use payment mechanism reinforces the value proposition. This applies to the payment tool, point of sale equipment and billing procedure. This reflects the fact that the value of information and personal travel options will vary by time of day, journey purpose, network status and a wide range of user characteristics. Thus, at any point in the trip chain, users are willing to pay for a package of mobility (ie information, departure times, journey times etc) which fulfils their needs. The payment system extracts this value. Fallback procedures are readily available for system breakdowns (including loss of payment tool) and billing queries. The complete mobility chip can be embedded in a number of media.

Shifting the Paradigm: How it was achieved?

In many ways the 2050 mobility system could have been accurately predicted. Demographic, economic and lifestyle/social trends were well known. These covered increasing prices of fossil fuels (linked to scarcity), an ageing population and older participation rate in the workforce and increased numbers of single person households.

Perhaps of equal importance were the interactions between the underlying growth, at the turn of the century, in the public's recognition of the importance of the environment and of environmental policies. There was increasing consensus and understanding of the cause and issues linking climate change, increasing concern about health and 'urban quality' risks from pollution and a growing consideration of sustainability. The proportion of the population willing to actively change their lifestyles, actions and consumption patterns in order to reduce their own environmental impact was rising.

The oil crisis of 2008 wasn't a short lived blip, rather the beginning of an exponential price rise which catalyzed this increasingly prevalent, but still largely latent, demand for environmental change, provided transport systems that met increasingly complex lifestyles and offered value for money.

Added to the mix were a number of best practice approaches implemented by a number of charismatic leaders. These leaders had implemented innovative sustainable policies, from London, to Paris, to California, to Brisbane, which were seen to have an impact. They were ripe for exploitation.

The private sector responded with real innovation in flexible "light" infrastructure development, implementation and management. To the private sector, the primacy of mobility as a policy area allowed convergence between technologies in related sectors (eg back office management systems from finance and health being adapted and converged with the new mobility lifestyle back office/customer service requirements).

A virtuous circle of best practice examples, environmental mood and imperative, funding from new green charges, political consensus and binding targets meant that change was not only possible, but also unstoppable.

Looking back at the scenarios of the “late 20th century crystal ball gazers” presented in the introduction, it can be seen that each has had some relevance to the emergence of our 2050 mobility system. Technology has been a fundamental tool for creating this new system (Perpetual Motion Scenario); sharp oil prices have not led to regression but catalyzed progression (Tribal Trading Scenario); green cities are the focus of activities and innovation (Urban Colonies Scenario) and legislative, political, public (and private sector responses) have been in harmony (Good Intentions Scenario). However, it has been the synergistic relationship between factors within each of these scenarios which has led to the real paradigm shift we have witnessed by 2050.

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Britain in 2050

Iain McMillan

By the end of the year the UK will have a long term carbon reduction target enshrined in the Climate Change Act. The Climate Change Committee, the body set up under the Bill before royal ascent, has already begun work and is likely to advise government to increase the target from 60% to 70-80%. In Scotland, the devolved administration has set out a mandatory long-term target to achieve an 80% reduction in emissions by 2050, equivalent to emissions reductions of 3% each year. But Scotland cannot contribute alone to emissions reductions. The Scottish Government does not have powers, for example, over the generation and supply of energy, the taxation of carbon, the conclusion of international emissions reduction agreements or the setting of emissions reduction standards of products. So, a team effort will be required with the rest of the UK and the EU.

In 2007 the CBI brought together a high level CEO task force on climate change which produced a report at the end of the year. From this work we know broadly that meeting these carbon reduction targets will require a doubling of current levels of energy efficiency and a halving of the carbon content of the energy used in the UK economy compared with today. Put another way, by 2050 each of us will be limited to a carbon diet of 2 tons of CO₂ per year. In this article I investigate what this means in detail and what we need to do to get there.

A decarbonised energy mix

It is difficult to imagine the UK in 2050 where our energy supply has *not* switched from the current reliance on fossil fuels to one where there is a greater diversity of supply including more use of nuclear power and renewable energy, in particular wind, solar and tidal.

However, fossil fuels will still have a major role to play and their continued role in the energy mix will mean that technologies that take carbon dioxide emissions out of the power generation process have a large role to play. In particular, carbon capture and storage (CCS) is likely to be commonplace by 2050 - most coal fired power stations are likely to use CCS to capture their emissions and nearly as many gas powered plants. The World Business Council for Sustainable Development (WBCSD) estimates that by 2050 8 billion tonnes of CO₂ could be captured yearly from coal-fired power stations.

Driving this fundamental shift in energy mix will be a global price for carbon, which will be created through a number of inter-linking regional cap and trade schemes. Collectively these schemes will place a global cap on GHG emissions and force all emitting sources to trade internationally in carbon permits. This will be underpinned by a series of international agreements on climate change that limit the emissions of greenhouse gases (GHG) into the atmosphere.

In the UK we have an opportunity to develop a low carbon energy footprint by 2050 because in the next 20 years we need to replace most of our energy system. This is estimated to cost in the region of £100bn. To support this investment in the energy sector and develop low carbon technologies more broadly there will need to be a significant increase in current RD&D support. We will also need to realise a streamlined planning system that delivers the necessary low carbon generation capacity in a timely manner.

Electric homes

The WBCSD suggests that only electricity will be available for consumption downstream in transport and buildings. This would limit the responsibility for GHG emissions to generation and industrial sites. Those in favour argue that by limiting GHG emissions to a relatively small number of upstream facilities it will make the control of emissions much easier, taking it out of the hands of billions of consumers.

Creating an electric economy means that households will no longer be supplied by oil, gas or coal. Currently direct emissions from households account for 30% of the UK's GHG emissions. If these direct emissions are relocated upstream, the focus for action at household level will be on using less energy – or energy efficiency. According to one source, energy efficiency will need to increase at 2% pa if we are to meet our long term targets.

This means that the 2050 home will be equipped with technologies such as smart meters that help us monitor the real time use and cost of energy– there has even been some suggestion that these meters will be programmed to turn energy supplies on and off depending on the time of day and the flow of energy across the UK. Forum for the Future suggests various new products such as kinetically powered i-Pods which will be powered by the movement of the user or u-grow indoor hydroponic and aeroponic allotments which make use of indoor space such as wardrobes to grow food! Other ideas include a link between consumers' fridges and retailers which will automatically trigger deliveries when required.

The challenge of course is not just to ensure new homes are built to meet our long term carbon reduction goals, but to retrofit the existing housing stock, 75% of which will still be standing in 2050. Government already has plans to ensure all new homes are zero-carbon by 2016 and new commercial buildings are zero carbon by 2019. Persuading householders to change their behaviour will require a concerted effort from government and the business community to provide information that markets energy efficiency in a way that people understand, to set energy efficiency standards for household appliances such as TVs, washing machines and ovens and incentivise changes through rebates on low carbon products or financial packages that make low carbon technologies affordable.

E-cars & H-cars

For the transport sector, an electric economy would support the diffusion of electric vehicles on the roads. However, electric cars will not be the only option available. Work by Shell indicates that by 2050 both electric and hydrogen cars will be widely available. And CBI work with McKinsey suggested that by 2030 at least 10% of all cars in the UK would be hybrid and together biofuels, electric plug-ins and hybrid cars could account for reductions of 25mtCO₂ by 2030.

As with buildings it is as much about the energy source as the use. All vehicles will also need to be more efficient, so that less electricity is generated upstream. The CBI climate change task force commissioned some carbon analysis from the consultants McKinsey which indicated that by 2030 all new private cars will be 40% more efficient compared to 2006. By 2050 work by the WBCSD suggests more efficient vehicles and also more public transport, especially rail following the example of the highly advanced and efficient Japanese rail network.

And as with homes, the policy framework that brings about these changes will include a mix of standards (for carbon dioxide emissions from vehicles or engine efficiency), support from government in the form of procurement for alternative vehicles, information and incentives for consumers to encourage purchases of more efficient vehicles, road pricing schemes, and also investment in the public transport system.

A shift in business operations

Any shift in our economy on this scale will involve a massive reallocation of resources in the economy and therefore a re-thinking of business management practices.

By 2050 the challenges for sectors such as steel and chemicals competing in global markets, where competitors do not need to take into account a price of carbon, will likely be offset by international agreements that secure a global price for carbon. New technologies will make these industries more efficient, and work is already underway to develop new low carbon technologies through RD&D initiatives such as Ultra Low CO₂ Steel (ULCOS). Switching fuels is also trailed as a possibility for the industrial sectors as well as combined heat and power.

The reallocation of resources also brings opportunities to develop new products and services. Estimates suggest that global markets could be worth \$1 trillion in the first five years of a global deal that limits GHG emissions. Taking advantage of these opportunities, new business models will be created which place carbon at the heart of management strategy – efficient and effective carbon management within the business and also down supply chains will reduce costs and wasted energy and so become the new token of a successful business.

In practice this could mean updating old equipment for the best available technology on a regular basis, and not just when the equipment is worn out. It could also mean implementing closed-loop ‘industrial ecology’ systems for business where business practice imitates nature –energy throughout the supply chain or industrial process is recycled and reused so that none is wasted.

All this activity will develop a new ‘green collar’ skills sector. This will be driven by the increasing demand for specialist environmental skills (e.g. energy efficiency experts, carbon traders), more traditional skills (e.g. in science and engineering) as sectors who need such skills seek to expand their activity to meet climate change objectives (e.g. the nuclear industry or flood defence engineering) and the ‘greening’ of existing jobs (facilities or logistics managers will understand and act on the carbon implications of their roles and decisions).

In our report we suggested that business must be pro-active if it is to take advantage of the benefits of a low carbon economy. The CBI is putting these words into action by developing new standards for measuring corporate emissions. In a 2050 low carbon world, reporting GHG emissions is very likely to be the norm for all businesses globally.

Carbon diets

The CBI's Task Force on climate change also found that if consumers are empowered, they could be the biggest drivers of change in the economy and in the business community. Our analysis concluded that they control or influence 60% of the UK's GHG emissions through their lifestyles choices at home and through their shopping baskets.

Consumer research indicates that the current market for green products is growing but still remains relatively small. Improved consumer information, incentives and opportunities that are reliable and consistent will help consumers make low carbon choices.

By 2050 it is likely that consumers will be demanding low carbon, energy-efficient products without giving it a second thought. This demand will have generated competition among business to provide the most efficient, lowest carbon offering. So that, just as the current A-G labelling for fridges has become the norm, by 2050 it is likely that we will make similar purchases for all household goods.

Carbon literacy will be key to supporting this change. Just as the UK developed a new generation of carbon literate school leavers and graduates, so by 2050 we will have spread carbon literacy across the population. In the transition, there is a role for both the government and business to support this move with better information, better financial offerings and energy efficient standards.

In this market for mass green consumerism, consumers as voters will likely have emboldened government to take decisions that enforce a long-term low carbon future. New voter awareness could make personal carbon allowances a reality. In a world where carbon is constrained to 2tCO₂ per person, a personal carbon allowance scheme would allow each individual the choice of how to use their 2 tons – if they don't use it all they could trade with those that want to use more. For the time being, as large multinational businesses become accustomed to the emissions trading scheme in the EU, it seems difficult to imagine how the man on the street will cope with personal carbon trading, but it is possible that in 2050 this will just be another part of life. Perhaps, like counting calories, we will discuss our carbon diets.

Everyone's business

It is worth remembering that the cost of not taking action is too high to ignore. If we don't address the rising level of GHG in our atmosphere, we will leave the UK, including Scotland, vulnerable to catastrophic climate disasters including flooding, very cold winters and very hot summers. Although warmer summers are often seen as a welcome benefit of climate change, in fact, extreme temperatures are likely to disrupt business supply chains particularly as suppliers are located in areas of the world more vulnerable to changing weather patterns.

To ensure that the risks of climate change are managed appropriately and GHG emissions are stabilised and then reduced in the coming decades, we all have a role to play. Action is required now to ensure that by 2050 we have a secure low carbon energy mix in the UK. This will need to take place alongside a shift in the way businesses operate so that they are able to adjust to a low carbon UK in which consumers are demanding low carbon offerings.

Iain McMillan CBE, Director of CBI Scotland

Going backwards and forwards

Ian Marchant

It would be easy to look back in anger. Despite the first warnings published in the *New Scientist* a century ago, in the 1950s, it wasn't until the first part of the 21st Century that climate change was taken seriously enough to make genuinely urgent the finding of practical ways to tackle it. There was across-the-board agreement on the underlying causes of our problem – a global economy over dependent on depleting resources like oil and our profligate use of energy in general – and agreement about how to solve it.

I remember the days before then, where world leaders would go to strings of international climate change conferences and proclaim the need for us all to act with urgency. Then, with some fanfare and little sense of irony, they would agree a set of targets way beyond their term of office. No-one would get away with that kind of thing nowadays.

As we sit in 2050 looking back, it is amazing that we appear to have achieved our goal. I'm not going to run through the numbers, 25% of such and such by so and so, this or that technology which came along in twenty-whatever delivering x million tonnes of y and z. The world changed in the last 40 years because of changes in attitudes and behaviour; and the human capacity for ingenuity and survival. That is the important story. Humanity put its own future on the brink – and it was people who turned it round.

Solving the problem, and doing it in time, was always going to be tight. Some people thought it would take something like a Biblical flood, or the lights going out for a long time, to wake us up and at times I feared they were right.

Now our economy is not dependent on global oil prices, nor on energy sources from distant suppliers and with this comes energy cost stability. And of course, our strong sustainable energy industry also brings employment and direct economic benefit to communities, especially in remoter areas of the country.

Everyone had to do something to make the change happen. The professionalised environmentalists played an increasingly leading role as they realised that climate change threatened everything – and the arguments of some of their own, to oppose all windfarms as 'blots on the landscape' for example, became untenable. Energy does not come for free. Those in the environment movement who preferred academic discussion lost out to those favouring practical action - working with the energy companies and other agencies to deliver sustainable energy on the ground and in communities.

In those early days of confusion and prevarication many sought the silver bullet solution. Energy efficiency was pitched against wind farms, offshore against onshore, heat against light, biomass against gas. We even had arguments over home or office working. The media led by extremes and polarisation - and politicians and single-interest groups felt compelled to follow.

But all that changed. That shift was given huge impetus by rises in prices for oil and gas. People didn't want to depend on unstable regimes in far-flung countries for their energy, and wanted more of it to be produced at home. A series of regional disputes over scarce resources brought home the reality that energy security delivered by more local, sustainable sources was an important part of national security.

That attitudinal change was perhaps one of the most important. It meant we made progress with, for example, wind farms, the grid system and basic energy efficiency early on; in parallel we developed the other solutions like marine energy and carbon capture as they matured. Instead of being criticised for trying to build too many wind farms, energy companies were scrutinised for their success in delivering green energy solutions.

Positive action came when leading politicians put forward a compelling message that economic prosperity depended on environmental stewardship. Those who could communicate this, and crucially those who delivered on their promises won the argument and the votes. And when the quiet majority who supported clean energy finally started to raise their voices above the antis who had hitherto had a clear run, the entire tone of the debate was changed.

Legislation which made politicians more accountable before each election for their actions on climate change and energy also concentrated the political mind wonderfully. A comprehensive strategy and genuine action plan across all sectors was agreed. For example, the planning system helped rather than hindered. The investment was made. Carbon became an everyday commodity. Saving energy earned cash and the low carbon economy, low carbon life-style became a reality. We made good progress on smart meters once government finally mandated that all homes should have one. Microgeneration became more efficient, cost-effective and commonplace once we got local housing planning working properly and created the type of financial incentives that encouraged individuals, energy companies and local authorities to work together.

Another significant attitudinal change occurred, similar to the loss of credibility experienced by the Flat Earth Society (still going and still committed to their mission: "*Deprogramming the masses since 1547*"). People who favoured opinion over fact were still being widely quoted well into the new century, challenging whether human impact on climate change was real and whether green power generated in this country could really help make us more secure. Thankfully those days are gone now. Science must always be open to challenge. That is part of its ethos. Open debate is a foundation of any democracy, but virtually all commentators are now more circumspect than ever in seeking to create informed debate rather than ill-informed shouting matches.

It took us a while to change from full-blown love affair to occasional fling when it came to our beloved cars. Even so-called petrol heads began to convert to the fuel efficient car, and then the electric vehicle really made an impact. *Top Volt* is still a favourite amongst the country's television viewers. Our conversion to electric vehicles and high quality public transport for mass renewable-powered commuting and urban transport only really took off when we mastered energy storage and conversion, but the credit is due to innovators like the Tesla car company, and Shai Agassi. By 2012 Israel had become the first country in the world with more electric vehicles on the road than petrol or diesel powered, and the leap to cheap electric powered cars in emerging markets such as India and Indonesia saw use of electric vehicles expand exponentially.

The energy industry had to change too. Those companies that thought it was all just about producing energy went into decline. Those who realised it was about energy services, those who adapted, innovated and invested in diversifying their portfolio, survived. We produce the most important product – energy really does make the world go round; but using it well is valued just as much as producing it in the first place – and that is where we have travelled.

In 2008 I set a target of reducing the carbon intensity of SSE's electricity generation by half by 2020. Little did I know then that it would be something like 90% by 2050. I wouldn't have thought it possible. But look at what happened with technology. Look at computers – I can hold a machine that is four million times more powerful in the palm of my hand today than I could in 2010. I remember that in 2010 I had great faith in the power of human ingenuity. Thank goodness we got the changes in attitudes and behaviours that meant that was put to good use.

Ian Marchant

Chief Executive of Scottish and Southern Energy
Chair, UK Business Council for Sustainable Energy

Finding Celtic Ecotopia **Michael Northcott¹**

The Energy Revolution

It is doubtful Scotland would have been able to meet its Kyoto 3 commitment to reduce its carbon dependency by 90 per cent by 2050 if it had not been for peak oil. As experts had long predicted oil production began to decline after 2012 because there was not enough readily available oil left in the ground. The price of oil rose from \$300 to \$900 a barrel between 2012 and 2025 and for most people driving and flying became too expensive. The streets got quieter and less polluted as electric buses and delivery vehicles increasingly replaced cars and trucks. In rural areas local councils reintroduced bus services that had disappeared in the Thatcher era, supplemented by electric taxis and postal vehicles. Many people gave up owning cars as urban car clubs, begun in 2002, spread to rural areas. As the streets emptied of 'private' cars people also took to cycling and in the major cities 40 per cent of all journeys were made by bike by 2030. To aid in the transition local councils put in physical separation for on-road cycle paths, reducing fear of accidents among novice cyclists.

Electric bikes and cars were the other crucial innovation. Those who could still afford to run their own cars increasingly moved to electric cars though many others went over to electric tricycles which came with canopies and wind screens to protect their occupants from the weather. A Scottish entrepreneur went into a business partnership with the largest Chinese electric bike producer and set up a manufacturing plant in Port Glasgow which brought much needed jobs into an area that had formerly been a major producer of car tyres and car parts. The factory turned out tandems, tricycles and bike trailers as well as bikes.

The large displacement of transport from oil to electricity put increased strain on the national grid. But the European Commission had begun work in 2010 on a new high voltage direct current trans-European electricity grid using Concentrated Solar Power gathered in the deserts of North Africa. Algeria and Jordan began work on CSP generators in 2008 and engineers added power storage facilities that used underground lakes of brine, and granite blocks to ensure stability of supply. Undersea power links were laid between Algeria, Gibraltar and Spain, and power utilities installed new switching gear across Europe to convert high voltage direct current into alternating current. By 2015 this new solar input into the grid had reached Scotland with the aid of new underground electric cables run alongside the two new North-South rail lines commissioned by National Rail in 2011. Gradually houses and offices across Scotland were converted from oil and gas heating to electricity and by 2030 every building in the country was powered by solar electricity.

The new rail lines made a significant impact on the carbon footprint of travel beyond Scotland. Whereas in 2008 only 1 in 5 journeys between Scotland and London were by rail, 4 out of 5 were by rail by 2020 with the rest mostly being made by express bus and a small number still by increasingly expensive planes. Dedicated bus lanes on all motorways significantly improved the speed and reliability of intercity bus transport and investment in the quality of buses saw the introduction of on-board catering, at seat movie screens, wi-fi and toilets.

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The bus lanes included guided wheel systems and had crash barrier separation from the other lanes and were able safely to achieve speeds of 100 miles per hour. The move from planes to ground based transport was stimulated both by the fuel price rise and by the worldwide carbon taxation scheme agreed in Kyoto 3 in 2020 after the eventual abandonment of failing carbon markets.

International travel also went through rapid change. After 2020 taxes on air travel under Kyoto 3 were gradually raised to a prohibitive level. Academics, businesses, civil servants and professionals began doing a lot more communication through video conferencing, aided by further advances in holograph and sound recording techniques. And long haul air travel declined as the former subsidy to tourist class seats from business class began to disappear. But international air travel did not disappear altogether. At first Richard Branson's introduction of an air ship in his Virgin Atlantic company was seen as a gimmick but when he began to run air ships on biofuels and solar power and to achieve times of only 12 hours for the transatlantic trip at a tenth of the price of jet planes he began to attract a growing proportion of the transatlantic market. Solar power on airships came from the new spray on solar cells that were used to coat the helium filled air ships. The journeys were not so reliably scheduled as jet planes since air ships fly at only 1500 feet and so must negotiate storms and winds in a way jet planes at 37000 feet do not have to. The journeys were also less smooth given turbulence at low altitudes but as compensation the wide space frames in the new air ships gave room for air-sprung seats.

The Agrarian Revolution

Since Europe had taken a lead in CSP European businesses were in a position to assist agrarian regions in Africa, Asia and Latin America to make the same transition to solar and under carbon debt arrangements introduced in Kyoto 3 they were required to assist developing countries in the energy transition. Two billion people in the South still living in rural areas and directly off the land benefited from the new solar energy economy as it spawned new micro-solar technologies. These were the ideal solution in areas that lacked an installed or reliable electricity grid. The move to a post-grid approach in electricity mirrored the earlier adoption of mobile phones instead of landlines in Africa. Heavier appliances such as cookers, washing machines, fridges and air conditioners were redesigned for post-grid societies and were powered by a variety of fuels including biogas from animal and human waste and local Concentrated Solar Power generators. These generators also provided power for electric bikes and rickshaws, which significantly improved mobility in the developing world.

Locally generated power enabled many rural villages and subsistence farming communities in the developing and developed world to recover a level of self-sufficiency and local governance that had been lost under former fossil fuel driven development policies. This move to self-sufficiency in energy also helped with the transition to the new low carbon food economy that was spurred by Kyoto 3 carbon taxes on land use, greenhouse gas emissions and on international transport, including air flown, shipped and trucked containers. The rising prices of staple foods that began in 2008 led many countries to move away from the now defunct World Trade Organisation project of an internationalised food economy. Politicians in both developed and developing countries began to see the importance of sourcing food, fuel and fibre from the home country wherever possible.

Another key element in this shift was the replacement of the inaccurate twentieth century measure of economic activity called ‘Gross Domestic Product’ by eco-footprint accounting methods – the Ecological Wealth Index – under a UN/OECD/World Bank/IMF agreement on accounting and financial reforms in 2025.

In Scotland eco-footprint accounting had significant effects in the fishing, sector. Fishing communities right across Europe lobbied successfully against the international fishing regime run from Brussels and in 2022 Brussels adopted a local low carbon fishing economy in which local communities were granted sovereign rights to their own coastal resources to a new territorial limit of up to 150 miles. Fishing within these limits was only permitted from the nearest ports whose fishers worked with the new dispersed fisheries service of civil servants and scientists. Under the new regime large international trawlers were banned and smaller local boats used a mix of solar, wind and biofuel. In some areas trawling was banned altogether in favour of creeling and other traditional and more sustainable fishing methods.

In the farming and estate sectors in Scotland land use emissions taxes and eco-footprint accounting had dramatic impacts on land use. Sporting estates were forced to end their over-dependency on deer shooting for income since the excess weight of deer on the land had turned soils in many highland areas from carbon sinks into carbon emitters. Tax credits for working carbon sinks and for land area biodiversity counts encouraged estate managers to replant indigenous forests, shrubs and plants. But many of the estates were eventually put up for sale and were bought by local crofters and residents under land reform legislation. Like the pioneering land reformers on the Isle of Eigg the new community owners planted indigenous forests. On the mainland these forests provided home to reintroduced species including beavers and wolves. Many community trusts also installed local renewable electricity supplies, again on the Eigg model. The new forestry and energy projects provided many opportunities for small businesses including ecotourism and craft-based activities such as wood carving, furniture making and the manufacture of zero carbon wooden kit houses.

With the introduction of carbon taxation on greenhouse emissions from livestock after Kyoto 3, and the rising costs of animal feeds, there was a two-thirds reduction in farming livestock across Scotland by 2030 and this helped the farming sector achieve substantial reductions in greenhouse gas emissions. Intensive pig and chicken facilities also became much more costly to run and many closed down after the new welfare standards introduced across Europe in 2025, combined with the rising costs of imported feeds. However after innovations in cattle cake and grass diets which reduced bovine methane emissions dairying continued and became more profitable with the ending of imports of milk and butter into Scotland from Europe as raised transport costs made it uneconomic.

Intercontinental transportation of fresh foodstuffs already grown in-country became uneconomic worldwide with rising shipping costs and carbon taxes. This significantly reduced food waste. The same factors made Southern and Central Europe more profitable places to rear livestock because the warmer temperatures require fewer imported feeds. Soft fruits, citrus, olives and other fresh produce that could not be grown in Scotland continued to be imported by ship and truck although the transnational importing of foodstuffs from beyond Europe became increasingly rare as African and Asian countries became more self-sufficient in food and devoted less land to export crops.

Local councils in Scotland played a significant role in the agrarian revolution as they used compulsory purchase powers to create new market gardens on the edge of cities and towns. Every Scottish city and town is now surrounded by a green belt of between one and fifteen miles width constituted of allotments and huts where urban residents grow much of their own food, keep chickens and pigs in free range common areas, and camp out on long summer evenings and enjoy communal eating and ceilidhs.

The Ecospiritual Revolution

As the post-carbon society advanced it became clear that consumption patterns would also change. Mandatory and rigorous eco-accounting revealed the true costs of business, consumption and marketing activities and visited these on the actual prices of goods and services. Increasingly people were looking for goods that lasted and were repairable. This produced a revolution in manufacturing and servicing and created many new jobs in repair and reuse. It had for example significant effects in the computer and mobile phone markets. Gone were the regular upgrades of software and hardware that required vast increases in computing power and saw the junking every year of hundreds of millions of electronic devices. With the international ban on shipping of such goods after use in 2025 software and hardware designers turned their skills to getting more from less in terms of information and energy use, and to the repair and upgrade of existing products.

The lifestyle and business changes provoked by oil price rises, carbon and waste taxes, and ecological footprint accounting were more dramatic than politicians or business leaders had anticipated. As citizens engaged in practices which reconnected human dwelling, eating, making and travelling with the renewable capacities of the planet they began to find sources of satisfaction in the activities of daily living that had diminished in the advertising-fuelled wastefulness of the late twentieth century. This provoked a new eco-consciousness and was accompanied in Scotland by the resurgence of Celtic religious practices of both pre-Christian and Christian varieties.

The Protestant revolution birthed capitalism in Scotland and in other parts of Europe which eventually led to the disconnection between consumer society and the earth system by the late twentieth century. The post-carbon revolution stimulated a reconnection with the renewing capacities of the earth system, and a new respect for the available energies of the sun. People once again learned to live off the daily benison of the sun's energy on the earth, and the living biomass it produces. And they no more did violence to the earth system by burning stored sunlight from under the ground. This new 'dwelling in the light' for pagans and Christians alike occasioned a renewed appreciation of ancient festivals of light from the mid-winter festival of Christmas to the summer solstice. And the Celtic cross, with its superimposition of the cross on the sun, became the defining symbol of the post-carbon revolution in Scotland.

Michael Northcott

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Climate Change – How Did We Meet Our Targets?

A retrospective from 2050

Simon Pepper

Looking back, it was an unnecessarily traumatic transition. The facts were well known; the technical potential was there (although investment had been delayed much too long); the global machinery was available. We only needed the will to change 3% per year – easily achieved by sensible lifestyle adjustments alone until technological investment caught up. But we ploughed on, talking a good talk but changing little of real substance, for far too long. All the same, it could have been a lot worse....

2008 was the threshold year, when the gap between awareness and action was greatest.

The IPCC's 4th assessment report had stirred us from our sleep-walk, and Stern gave economic credibility to the case for early action. Governments were convinced; industry too. Investment strategies swerved in favour of energy efficiency and renewables.

But while a small segment of the public embraced the challenge with a zeal heightened by fear of catastrophe, the majority (often deterred by the zeal) refused to cotton on. The target of an 80% cut (albeit over more than 40 years) was too much of a challenge to comfort zones in what became known as the Age of Excess. An Observer opinion poll in June '08 had revealed that most people didn't accept the scientific consensus. This was evidence of the kind of collective self-delusion catalogued by Jared Diamond in his book 'Collapse', charting the history of declining civilisations. The 21st century repeat of this slow car-crash featured the over-exposed 'denial industry' and phenomena such as the 'China evasion' (why should I bother?) and the 'offset illusion' (I'll pay you to bother instead). The moral hazard of the latter was humorously illustrated by a stunt offering cheating lovers the opportunity to pay rewards to faithful couples so as to compensate for, and thus excuse, their own infidelity.

So governments upped the rhetoric, but still delayed too long with action, fearing the ballot box response. The SNP, which had gained power by removing road pricing, were only too aware of the contradiction, flourishing what seemed a daring piece of climate change legislation but which, as if to illustrate the speed of change, already looked seriously inadequate before the ink was dry. Without much more radical intervention, energy-inefficient Scotland would take a competitive nosedive in a world increasingly dominated by rocketing energy prices. The democratic exercise of denial and delay was inviting catastrophe. China's command regime – ever the contrast – moved swiftly ahead with dramatic energy efficiency targets of a further 20% by 2020, spurred on by their failure to achieve their first 20% by 2010.

Energy prices in 2008 provided the explosive charge behind a transforming surge in policy, rising to \$200 per barrel (after some ups and downs) – often more than \$10 rise in a single day. Scotland's own poor took the brunt – they had nowhere to hide. Their principal areas of expense – housing, transport, food – were all hit, and in the resulting political panic, the inertia which had gripped all these sectors was finally broken. Scotland was of course rich in renewables – hydro, wind, tide, wave and biomass – but it would take until the mid '20s for investment to bite seriously into the gap between demand and supply. Meanwhile we were mostly dependent on oil and gas.

However, energy prices turned out to be a godsend in disguise. They prompted blockades and even riots for a while, as badly affected interest groups struggled to come to terms with new realities, but the higher prices also drove energy efficiency with a vengeance. Wherever there were alternatives, people just took them. Diets simplified, 'trivial travel' was decimated, businesses took advantage of improved telecommunications, and holidays abroad dropped well below the ludicrous early 21st century projections of the airport operators. By 2015 half the population was largely vegetarian and sourcing most food locally; car-sharing and bus transport had multiplied (there was already little space to spare on the trains); and airport expansion began to seem like science fiction.

Fears of doom and despair at all this 'sacrifice' were interestingly wide of the mark. People started to discover more value in health, peace of mind and fellowship than income and status, and took pleasure in simpler things, enjoying the odd Sunday roast or holiday abroad more as a treat than a routine expectation. Collaboration paid huge dividends in areas such as transport. Quite soon it didn't seem so important to travel alone by car to work; public transport nodal networks flourished; everyone saved a lot of motoring expenses; congestion eased enormously, priority traffic flowed much more efficiently and we all wondered why we hadn't done this before. The streets were calmer, and 'community' began to mean something again.

Where there weren't alternatives that folk could afford, the government had to act with the far-sighted social statesmanship redolent of the founding of the NHS after World War II – also at a time of economic weakness. To combat steeply rising levels of fuel poverty, a massive retrofit programme was launched, supported by a new system of energy mortgages, to bring the housing stock up to standards as near as possible to the zero emission standard for all new housing already required by 2016.

Meanwhile of course, the same pressures were mounting globally, with impacts on Scotland too. Energy prices had much more serious impacts in the developing world. For a while, richer countries and individuals had all the cards – they could afford the energy, the higher commodity prices which resulted, and the means to invest in efficient technology and a whole range of adaptations. Although it felt painful to them in their prosperity, they, the cause of the problem, were relatively all right. Even in poor countries, the rich were comparatively OK.

But again it was the poor who were hit hardest. Disproportionately affected by the more dramatic manifestations of the climate and unable to afford the consequential costs, they suffered appalling hardship in unprecedented numbers. This was a blight on the conscience of the rich, but the rich world already had a rotten record of nursing its conscience with the rhetoric of sympathy and earnest endeavour. Despite the grand ambitions of the Millennium Goals, 73m people in 78 countries already depended on food handouts in 2007 (WFP); a 75% rise in food prices since 2000 had pushed an extra 100m below the poverty line by 2008 (World Bank), creating a food crisis in 36 more countries (FAO). And this was before the energy price surge. Mass starvation loomed on a biblical scale.

The climate played its own lethal part in this tragic drama. With world emissions still rising, the 2°C tipping point was destined to be breached by 2030. Storm, flood and drought set off the deadly dominoes of hunger, migration and political unrest throughout the developing world. Europe and the US, and prosperous enclaves in other countries world-wide, began to bar their fortress gates, fearing the hordes.

Behind the crocodile tears, callous survivalism prevailed, stirring resentment outside the walls, inviting new levels of guerrilla terrorism with its imaginative, multiple hits, contrasting with the single obvious targets of earlier years. Anxiety mounted; trade was threatened supplies; well-being was under serious threat. Global interdependence – the watchword of every world statesman - teetered on its rhetorical foundations.

The options were increasingly clear to world leaders. If they didn't respond to the 'politics of insecurity' (E3G) by forging a new level of equitable global collaboration, it would drive further polarisation with catastrophically damaging impacts.

Increasingly these forces converged on the agenda of world leaders, and a global cap on carbon was agreed in 2012, to take effect - none too early - in 2021. The struggle wasn't over; throughout the '20s and '30s there were military interventions by the G15 world alliance to enforce global regulation of carbon emissions, and the UN imposed sanctions to regulate food production, forest protection, mineral mining and water supplies for global benefit. But the cap on fossil fuels and the trading of emissions at regional, national and individual levels, along with a rising generation of low carbon technologies – the harvest of seeds of investment sown in the early 2000s - finally brought emissions under control. Temporary spells of rationing, here in Scotland as in many other countries, helped behaviours to adapt.

But in 2050 the future still presents desperate challenges. Rampant climate change persists – the legacy of past emissions - with unpredictable consequences. Sea levels seem destined to rise much further; low lying coastal areas are increasingly abandoned in favour of development on higher ground. Upward population trends took a knock in the transition years, due to widespread deprivation and disease, but are rising again as the emerging economies indulge in their own (energy efficient) materialist spree.

By 2030 Scotland was widely exploiting its wealth of renewables, exporting into the Eurogrid through a direct current interconnector, largely eliminating earlier worries of transmission losses and intermittency. Once the generation technologies were widely available at a domestic scale, there was a rush of interest in rural areas where energy was abundant, and land was available for small scale cultivation. The wealth of renewables (80-90% of the UK total) – nicknamed the 'new oil' - did wonders for Scotland's previously rocky relationship with England, yielding generous devolution deals which could be marketed as 'independence' while averting actual political separation.

As for nuclear, Scotland didn't need it or its colossal expense, noxious waste problems or other hazards. New nuclear technologies were adopted in other countries lacking other means of energy security, and the controversies continued, especially in the inevitable wake of accident and terrorist threat in less stable areas. Demand reduction, renewables and greater efficiency – especially in the industrial sector where only the fleet-of-foot survived - allowed coal fired power stations to be phased out in the '20s, leaving others to explore the benefits of Carbon Capture and Storage (CCS). Meanwhile hydrogen and fuel cell technologies have both found successful niches in the new low carbon energy economy.

Transport has changed beyond recognition. Gone are the days of exorbitant motorcars, capable of 200mph – now relegated, along with Concorde, to the status of exhibits in museums of the Age of Excess. By 2035 most rural households had at least a share in an electric car charged from wind or hydro, used as a ferry for short journeys to the nearest public transport node.

Road pricing forced economies on personal travel, leaving road-space for essential goods and services. Despite early alarmism, people still go by air when necessary; the airports of the early 2000s are more than adequate for a level of traffic which had already peaked in 2008, before even the victors in the airline price wars found fuel costs prohibitive, especially when fuel taxes were finally applied.

Rural parts of Scotland saw their own changes. Settled areas became populated more densely than at any time in the last 5000 years, supporting the new low carbon/low cost lifestyle dependent on vegetable growing and harvesting of wild meat from hill and sea, with internet-connected businesses exploring many a profitable niche. Hill farms in the north and west had collapsed under rising costs and declining profits in the absence of subsidy; wild land has become wilder, and a source of wild food for the populations in the hills and glens.

Elsewhere, livestock farms have survived in specialist high value meat production where inputs could be minimised, and farms have clubbed together to generate biogas from the slurry and slow pyrolysis of waste which also yields soil-improving charcoal. Crops are grown for local consumption, using cheap labour from the community. Precision farming and minimal cultivation are the norm, with direct injection of nitrogen to reduce emissions. In the hills and windy coastal areas, energy has been added to the range of farm enterprises, in response to a generous feed-in tariff to the grid. Forests, some planted, some naturally regenerated under reduced levels of grazing, now cover 25% of Scotland, sequestering carbon, replenishing soils, and providing many other benefits to increasingly self reliant local communities and the wider economy.

The cities struggled throughout the first half of the 21st century to control their own form of polarisation. Government-backed schemes to retrofit energy efficiency measures helped reduce fuel poverty; new dependencies grew between cities and their hinterland. But the big change was the massive investment in education and youth training schemes with a focus on the real needs of society in the new millennium. This reversed the cycle of alienation and crime, engaging young people in a different and more positive vision of the future. Immigration of Scotland's share of climate refugees threatened social disruption, but the scale of the movement was fortunately within our capacity to cope.

By the mid '40s the new direction for cities was bearing fruit under the leadership of an enlightened generation which flourished under powers devolved from central to local government, fundamentally re-setting priorities; cities regained their harmony, developing a poly-centric pattern of activity as many communities found their own identity and prosperity based on collaboration, minimised travel, energy-efficient technology and norms of behaviour which valued cohesion and security. The people have regained control of their streets from the tyranny of noisy, dangerous, polluting traffic. Increasingly, the elderly are cared for at home by family or in the daytime by co-operative neighbourhood groups similar to the playgroup model of earlier years.

So the real changes have been in society itself. The biggest challenge we faced was not so much technological but cultural - the reform of our human systems of organisation and values. People yearned for new ways of thinking about life and its purpose; religions adapted, as they always have, to new imperatives; liturgies emerged to comfort the fear of change and re-direct ambition.

Most conspicuous was how the most successful transition has happened in places where the norms of hedonism and greed – for which the Age of Excess has gone down in history – have given way to values based on global citizenship and community well-being, measured by indices of health, happiness and security, for us and for others. The new consumerism is more sensitive; ‘sustainable’ has joined ‘legal, decent, honest and truthful’ as a requirement in advertising; there’s a personal carbon credit card in every wallet or purse; waste isn’t wasted any more; materialism no longer rules; ethical and local are watchwords of procurement. We trade overseas more in knowledge than in ‘stuff’.

Ironically, the 80% target turned out to be the easy bit. It wasn’t nearly enough, but once we were over the threshold of public inertia and people grasped the enormity of the challenge, progress was not just surprisingly swift and painless, but enormously beneficial – for us in Scotland at least. Change isn’t so bad; in fact it can be irresistible. For example, a 99% reduction in the use of telephone boxes in less than 10 years might have looked like a threat in the 1970s, but it happened in the ‘90s (BT). It’s all about better alternatives.

But now comes the real test. There is of course an abundance of carbon-free energy – an almost infinite supply; we only needed to work out how to harvest it. The real challenges are the finite supply of non-renewable resources, and the threat of ecological degradation undermining environmental services, with a continually rising population. The world was already over-consuming by 30% in 2007, when only 1.5bn out of a population of 6bn enjoyed a moderate level of prosperity. With global numbers approaching 8bn, and rising consumption levels, the pips are squeaking. Already in 2008, resource rustling had started to spread like an epidemic – copper cables, steel bridges, railway lines...

So we’ve done our bit to avert the worst consequences of climate change, but the world still faces unimaginable stresses in the years ahead; the 80% emission reduction target was just an introductory course for beginners. The good news is that we have at least passed that test – we’ve graduated to the main course.

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**Adapting buildings and cities for climate change:
The low carbon building revolution – looking back from 2050**
Susan Roaf

J.K. Galbraith noted in 1958 that ‘conventional wisdom’ generally makes people indisposed to change their minds and reminds readers of John Maynard Keynes’ most famous saying:¹ *‘Conventional wisdom protects the continuity in social thought and action. But there are also grave drawbacks and even dangers in a system of thought which by its very nature and design avoids accommodation to circumstances until change is dramatically forced upon it ... the rule of ideas is only powerful in a world that does not change. Ideas are inherently conservative. They yield not to attack of other ideas but to the massive onslaught of circumstances with which they cannot contend.’*

At the turn of the 21st century the massive onslaught of the circumstances surrounding climate change, began to hit home as the first ‘Western’ climate shocks arrived: the 35,000 European heat deaths of 2003, the great billion dollar floods of Europe, New Orleans and Britain in 2002, 2005 and 2007 respectively. Politicians and designers started to take more seriously the need for effective action planning for climate change mitigation and adaptation. This necessarily entailed moving away from energy profligate and climate vulnerable building design. The Low Carbon Building Movement was born that dismantled the conventional wisdom of ‘Modern’ 20th century buildings.

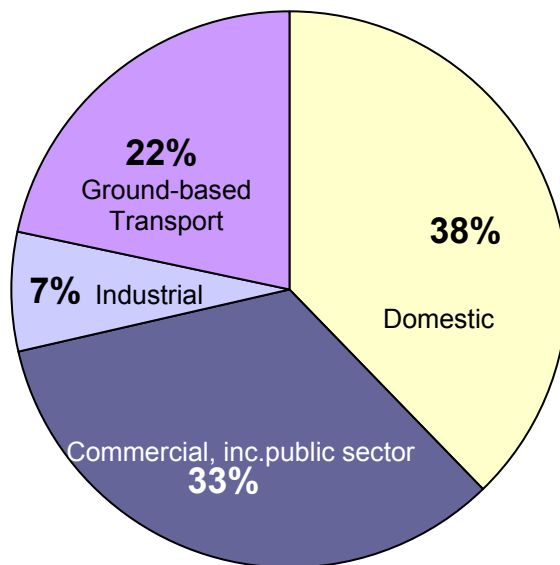


Figure 1. Sources of the 44million tonnes of CO₂ emissions from the city of London in 2005 excluding aviation (Source: Charles Secret).

Buildings were then the major contributor to climate change. Buildings use around 50% of all energy in developed economies and produced over half of all their greenhouse gas (ghg) emissions. Yet year on year fashionable buildings became more energy profligate. The more 'Modern' they were², and the taller³ and the more highly glazed they were, the more ghgs they produced. Out went the cry 'Adapt or Die'⁴, but many, including those who taught designers what constituted 'Good Design', took absolutely no notice⁵.

The smart money had already been moving quietly away from a generation of poorly performing buildings, described in Gensler's 2005 Report as 'Faulty Towers' because they soon became an investment nightmare in the tumultuous markets created by soaring energy prices⁶. Not soon enough for many who went under in the recession of 2009.

Conventional wisdom held on to the bitter end in the conservative property markets because there were so many vested interests involved. People knew what they knew how to do and had made sure over the years that they profited from it. For instance the lighting profession had developed standards that required excessive lighting. The air-conditioning industry had persuaded everybody that you really should not design buildings with opening windows. Some experts hypothesised that it was too noisy and polluted in cities to open windows, despite the fact that others had long been telling occupants that the air quality in air-conditioned buildings caused increased incidences of sick building syndrome and that air quality was better outside than in!^{7,8} It could be argued that in some cases the 'Standards' that were ostensibly developed to protect the interests of the general public often resulted more in the promotion and protection of the business interests of their drafters. Change was actively avoided in the Status Quo.

As clients and local authorities began to increasingly demand carbon neutral buildings, the spectre of the 'greenwashing' of that Status Quo rose over many fashionable edifices. The need for a genuine 'paradigm shift' in design became clear.

Up to the turn of the 21st century *efficiency* was believed to lie at the heart of low carbon building design but efficiency in building energy system design is largely about machines. The secret of real low carbon buildings lies largely in their design and construction. The end of the age of buildings that were 'machines for living in' was nigh.

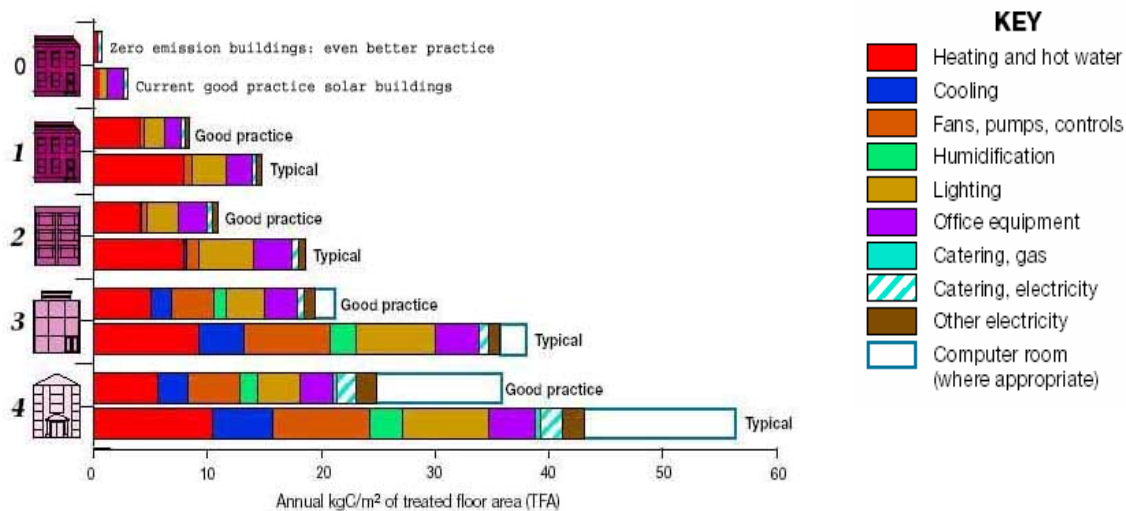


Figure 2. Air-conditioned offices use significantly more energy to operate than naturally ventilated ones. This figure shows office building types and their annual carbon emissions (kg carbon/m² Treated Floor Area) with (a) best practice and (b) typical (Source: Bill Bordass, 1990⁹)

Type 1: Traditional office building, shallow plan, naturally ventilated and typical of the traditional 19th and early 20th century buildings.

Type 2: Open plan and naturally ventilated buildings, such as became increasingly used after the 1950s when the demand for urban office space grew rapidly.

Type 3: Deep or shallow plan, standard air-conditioned building.

Type 4: 'Prestige' or 'fashionable' air-conditioned, probably deep-plan office building of the type increasingly popular with 'modern' architects and developers.

Type 0: Low Carbon Building with shallow plan, naturally ventilated or advanced nat. vent with type 0a operating on embedded renewable energy (apologies to Bill Bordass for type 0)

Architects began to understand that Low Carbon Buildings needed to roughly:

1. Halve the demand for energy with good architecture (-50%)
2. Double the efficiency of the machines in the building (-75%)
3. Halve the carbon intensity of the energy used to run the machines (-88%)
4. Get the rest of the ghg savings through load shaving and shifting and behavioural changes by the occupants (-90%+)



Figure 3. View from the top of the Burj al Dubai, the last and greatest of all high carbon buildings ever built (Source: Crichton).

In this way buildings could be run on a fraction of energy with over 90% fewer resulting emissions. But to achieve this building integrated renewable energy systems had to be developed. Some farsighted individuals had been experimenting with wind and solar energy and heat pump systems since the oil shocks of the 1970s. By 1995, early examples of what we call low carbon buildings had been built with fully integrated photovoltaic (PV) roves, the first UK example being an ecohouse in Oxford¹⁰. This was five years after the German government had begun their major investment in PVs which resulted their being the first global low carbon economy, only overtaken by China in the 2020s.

The great thing about the early low carbon buildings like the Oxford Ecohouse was that they demonstrated that once the initial capital investment has been made, integrated renewable systems produced energy that never increased in price. By 2015 we had the \$300 barrel of oil and the vulnerable poor in Britain were already dying in large numbers in winter from hyperthermia and in summer from heat stress. The problem was made worse by the huge investments in a new generation of nuclear and coal fired power stations that forced up the cost of delivered energy to astronomical levels, and caused widespread chaos when the electricity grid did fail during extreme weather events.

There had been a number of reports early on in the century that demonstrated how we could have reduced emissions from UK homes by 60-70% with an investment of around £200-250billion¹¹. That was around £10billion a year each year for 10 years. This was a fraction of the losses of the banking system at that time and would have covered the installation of widespread energy efficiency measures and solar systems in most UK homes.

Warnings that cities were on the ‘edge of a cliff’ and nations ‘under seige’¹² were largely ignored. Business as usual prevailed for too long in the sway of short-sighted politicians and the power of conventional wisdom. However the green shoots of a greener age had already begun to break through the concrete of the urban jungles and by the 2020s a new age of architecture had emerged that gave us the amazing stock of resilient, robust self powering low carbon buildings, set in solar cities, that we rely on today in 2050.

We had learnt by then just how the power of solar energy could be harnessed to supply so many of our energy needs^{13,14}. Back then in the UK, each square metre of a south-facing roof received around 1000 kWh of solar radiation during a year, and today of course this is around 1200kWh. This means that the roofs of most homes receive more energy from the sun in a year than is needed to provide their space and water heating and electrical energy. Even in rainy Scotland the myth was proved very wrong that ‘there is not enough sun in northerly latitudes to make solar energy worth the investment’¹⁵. The radiation that falls on UK roofs is now used to supply over 60% of all building needs in:

1. *Daylighting*: Careful design of a building to introduce sunshine or daylight into as many areas of a home as possible will significantly reduce the need for artificial lighting¹⁶.
2. *Passive solar heating*: including direct solar gain that reduces space heating demand by heating the air in the rooms exposed to the sun, and the walls of those spaces¹⁷.
3. *Active solar heating*: typically involves the use of solar hot water panels linked by a thermo-syphonic or pumped water system to the hot water tanks of the building¹⁰.
4. *Solar electric systems*: Solar electric or Photovoltaic panels generate electricity from sunlight and produce most power when tilted at around 30-40° to the horizontal and, in the northern hemisphere, positioned roughly facing south (south west to south east)¹⁸.
5. *Dehumidifying solar air-conditioning systems*: an emerging range of technologies with roof top solar collectors are used to power desiccant and absorption components that directly remove the water vapour (latent heat) from the air passing through the cooling system, used then to control the temperature and humidity of the air in the system¹⁹.
6. *Solar chimney convective cooling systems*: For millennia people in the Middle East have been convectively cooled by air streams driven by solar chimneys at the hottest times of year when pressure driven ventilation systems fail in high pressure weather systems²⁰.
7. *Rain screen cladding*: Integrated PV systems are now often extremely sophisticated in their construction and in their balance of system design, and increasingly use innovative design features such as rain screen cladding for roofs and building walls in urban, suburban and rural locations²¹.

What led to the Solar Age?

Since the 1970s we have known that solar energy had to be the answer to providing free, clean power to the masses and that this could be done with the right political will²². What eventually proved to be the trigger for change in this field was the involvement of cities. They did not suffer from the myopia and a four/five year elected executive and were directly accountable to their local voters. Every one could see where the buck stopped there.

Oxford was an early solar city, convinced by the success of the Oxford Ecohouse project. The Oxford Solar Initiative brought together business, government, planning, and citizens to make solar power happen in the city²². In 2003 the city had several clear objectives:

Goal One: 10% of all houses in Oxford will have solar systems by the year 2010.

Goal Two: To implement a capacity building programme through Oxford City for the training and educating of its citizens and officers in CO₂ mitigation strategies.

Goal Three: To establish strategic alliances between local government, households, business organisations, energy supply companies and community organisations to fulfil Oxford's CO₂ reduction targets.

Goal Four: To initiate and implement a solar campaign to support local CO₂ reduction initiatives at every level within the Oxford community from primary school children to business leaders.

From such simple aims grew the Oxford Solar Initiative and similar city initiatives around the world. Gradually the allegiances and technologies were built that provided the firm foundations for the low carbon economy we enjoy today. We now have the technology to survive in comfort in buildings and cities that are resilient to the twin challenges of climate change and fossil fuel depletion without the need to develop unaffordable and unclean generating capacity.

What was needed was the political will to make this happen but that was never going to happen from the top down. It was the cities of this world, and their citizens, who were minded to act, and did so effectively, when the massive onslaught of circumstances with which they could not contend eventually did arrive.

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The View from 2050

Scottish Youth Parliament

Well, years have flown by but many things are still the same. Parents despair at their teenage offspring's' questionable music taste and the papers slam the politician of the day. Under the surface though there have been massive changes. These changes fall into three main categories: home life, renewable energy use and government response to business. While they impact on the public to varying degrees each area has been key in ensuring the carbon emissions targets are met and that human life on this planet can continue to be a reality.

While even extensive media exposure of sustainable development issues was never going to convince the general public to make those vital life changes that the government so dearly needed to meet targets, it was found that social initiatives gave many the much needed push to adopt more environmentally friendly lifestyles. Provision and fitting of insulation for elderly peoples' homes and mass production of reduced cost energy saving light bulbs brought this way of life straight to the public, a realization of the cost effectiveness of these measures was the natural accompaniment. Further the push for all new homes to be built with energy efficiency in mind meant that previously elusive habits like turning off lights and not leaving TVs on standby became second nature for most people.

Where Britain really came into its own at this time was in the renewable energy field. The realisation of the great energy potential held in its shores lead to increased support for research and development. The area that really stood out was wave power, coastlines, particularly in northern Scotland, proving perfectly suited for making the most of this expanding technology. Moreover it was another government push to make most communities self sufficient in terms of energy- promoting solar panels and wind turbines being incorporated into design, that put Britain on the map in terms of renewable energy and allowed it to decrease its reliance on unclean energy sources.

Another key development was the government realisation that big business, as the main offender in carbon emissions, had to be brought in line. An initial softly softly approach proving unfruitful it was discovered that incentives in the form of subsidies for those companies seen to be taking part in environmentally friendly practices caused the greatest change. Positive public response to those companies that did adopt eco-friendly policies also lead to increased co-operation from business.

Gaining public support and commitment to cutting emissions was instrumental in the successful meeting of the targets. Encouraging everybody to make small everyday changes that really add up played a huge role in cutting emissions and in creating a positive ethos in which renewable energy sources were celebrated and big business coerced into also playing its part.

One generation found themselves affected by this change more so than others. While the teenagers of the early 21st century were not the most emphatic or future thinking, as they grew so too did their understanding and involvement in energy efficiency issues. Many leading convenience driven lifestyles found this at odds with the rising cost of living.

As young adults faced with university loans, the prospect of mortgages and the rising price of everyday items, car sharing and greater reliance on public transport came as a matter of course. Enticed by exciting job prospects in the expanding renewable market as well as the savings to be made by making 'green' lifestyle choices young people began to embrace the trend perhaps more readily than other demographics.

Not only is the world a cleaner and healthier place to live in 2050, the co-operation that led to this change in the last half century has seen the human race also benefit!

Scottish Youth Parliament

The Long And Winding Road From A High Carbon Economy

Jim Skea

Without fanfare or a word in the e-press, Scotland and many other European countries passed an environmental milestone yesterday. 45 years ago the Climate Change Act was passed. It required Scottish Ministers, by 31st May 2052, to tell Parliament whether or not they had fulfilled their duty to bring the country's greenhouse gas emissions in 2050 down to a level 80 per cent below levels in 1990. Based on information prepared by her civil servants, Climate and Economy Minister Billie Wallace was able to sign off on the commitment and quietly bring an era to a close.

Climate change and the high carbon economy

Nowadays, we all worry about climate. How will we cope with the unprecedented levels of rainfall and intense storms that cause severe flooding and disruption in winter? How can we help vulnerable old people stay comfortable in summer? The mortality rate among the over-100s was a national disgrace in the summer of 2049 and again in 2051. How are our local communities coping with the influx of tourists seeking out our long sandy beaches and looking to build second homes? Even if we think it's hot, we have to remember that, by their standards, friends from other parts of Europe find it relatively pleasant. Of course, there are bright spots as well. Scottish agriculture has experienced a renaissance as new crops have become viable. The failure of the government to fully grasp this opportunity frustrates many.

But we now take it for granted that we live in what our parents and grandparents quaintly called the "low carbon economy". They spent hours driving kilometres to work, each in splendid isolation in their own vehicle, spewing out dangerous greenhouse gas emissions. We have the luxury of working at home or in local community hubs. When we do need to meet, our first choice is usually tele-conferencing. Occasionally we do need to risk the weather and floods and jump on a bus or train, or use our communicators to make a booking with the local car club, but at least we know that the vehicles are clean and emission free.

Our forebears' homes were even more extraordinary. They were essentially machines for turning fossil fuels into greenhouse gases. They leaked more heat than they used. When you hear our centenarians complaining about how hot it is, it's hard not to tell them that should have done something about it by reducing their emissions instead of moaning about the size of their "natural" gas bills.

De-carbonising electricity

Even if we delayed action far too long, we have to acknowledge the major achievement in getting from the carbon-addicted world of the early 21st century to the low-emission world we take for granted today. The first big step was to sort out the electricity sector. Electricity is the life-blood of our economy, even more so today than it was at the turn of the century. But then it mainly came from giant power stations relying on natural gas and coal transported from the other side of the world with no provision for capturing and storing carbon. The pathway from there to here was far from straightforward, and it has to be said that politicians early on simply did not appreciate the scale of the challenge they faced.

The key turning point came thirty years ago. The European Commission took to court 25 of the 27 Member States which were then part of the EU for their massive failure to meet the undertakings they had made on the deployment of renewable energy. Normally such a widespread failure would have led to matters being brushed under the carpet. But the extent of the gap between rhetoric and reality, coupled with soaring gas, oil and coal prices and the severe climate-related storms that started to plague Europe in the late 2010s, gave the Commission the opportunity it needed. Exploiting the public mood, it imposed massive fines on national governments and ploughed resources back into low carbon electricity generation, channelling the funds through Europe's regions and emerging small nations.

That was the turning point. From 2020 onwards, the Commission rapidly ramped down the emission caps associated with the EU Emissions Trading Scheme. All countries pressed ahead with the large scale deployment of renewable energy. In a way the delay was fortunate for Scotland. It allowed wave and tidal energy to be demonstrated by the time that really aggressive policies were put in place. Some historians have argued that, without the delay, Scotland would not have the thriving renewables industry it has today.

Scotland obviously took its own decision on the use of nuclear power, though a number of other countries took a different perspective. Worldwide, nuclear makes substantive contribution to electricity generation though the pattern of deployment is very uneven. But the controversy about the continued use of gas and coal for electricity generation has never really gone away. After delays in demonstrating carbon capture and storage (CCS), the technology gained market credibility towards 2030, buoyed up partly by high carbon dioxide prices. Electricity companies are vocal supporters of continued fossil fuel use. They cite the 90% reductions in emissions from CCS, our ability to import cheap kit from China and India and the flexibility that fossil fuels bring to an electricity system. But for the purists, 90% reduction is not enough. In response to pressure, manufacturers have stepped up capture efficiencies, but totally zero-carbon electricity from combustion is an illusion given the high price of bio-fuels.

Energy use in the home

The transition in energy use in the home was equally remarkable. Scotland and other parts of Britain made great progress in improving home energy efficiency in the 2010s. Utilities helped householders implement all the easy measures in these days. They filled cavity walls with insulation, topped up loft insulation and distributed LED lighting (as well as now obsolete "compact fluorescents").

But just as the electricity crisis struck they ran into a brick wall. All the easy measures had been used up. To get a step change in energy efficiency in existing homes, there was a need to implement more radical measures that were intrusive and cost far more money. Driven by the supplier obligations imposed on them by government and enabled by compulsory access powers, the utilities entered people's homes to install solid-wall insulation, under-floor insulation, solar thermal heating and triple-glazed windows.

In retrospect, the civil disobedience campaign that followed these policies should have come as no surprise. After a street in a former mining town in Central Scotland barricaded itself in and defied police and utility workers for two months the writing was on the wall. Compulsion was dropped and a new partnership/softly-softly approach was adopted. Increasingly, utilities worked with local authorities and NGOs. Information campaigns highlighted the enormous savings in energy costs from improved efficiency.

Eventually profligate energy use was stigmatised in the way that tobacco use and drink driving had been in the past. Today we expect our homes to keep their heat in. The few residual heating needs we have, after allowing for heat gains from fridges and freezers, can be topped up with low-carbon electricity.

Co-operation with manufacturers yielded quick wins with electric appliances such as washing machines, fridges and freezers. But back in the early 21st century there was a growing problem with electronics and communications. Old television sets gobbled up huge amounts of power compared to the holographic devices we now all have in the corner of our living rooms. Bizarrely, they used power even when switched off! But it was then that the digital economy was emerging and information entered the lifeblood of the economy, just as electricity had done previously. Inventing and exploiting new markets took precedence over efficiency and low emission levels. Having moved beyond silicon-based processing power and having consolidated the vast number of “gadgets” with which our parents cluttered their lives, electricity needs for information and communication have dropped dramatically since their peak in 2025. The same can be said of the huge amounts of power used by crudely designed communication masts and inefficient servers emanating heat which then had to be compensated by air conditioning.

Mobility

The last, biggest and hardest transition has come in the transport area. Today we look forward to these special trips to new places or to visit distant relatives and friends. Fifty years ago, cheap fossil fuel and “free” carbon meant that people could be taking to the air several times a year, or more if their business required it. The value of travel and new experiences had been de-valued by virtue of being commonplace. Today the cost of carbon, reflected in ticket prices, means this is out of the question. If it weren’t for the fact that biofuel makes up half the blend in aviation fuel, ticket prices would be even higher. In parallel, the expansion of high-speed rail travel has brought many benefits. It’s hard to imagine a time when we couldn’t take direct high-speed trains from Edinburgh and Glasgow to Paris or Berlin.

The revolution in local and regional transport has also been striking. The variety of options from which people can select to meet their transport needs is something our grandparents could only dream of. New technologies and new ways of working have managed to reduce massively the amount of work-related travel – commuting and business trips – that we need to do. Where commuting by public transport is not possible, car sharing is now the automatic choice for most people.

For leisure purposes, many of us still prefer to own a car, plugging it in overnight in our driveways or in the street to top up the batteries. This helps soak up the power being produced from renewables and other sources which wouldn’t otherwise be used. People who need a vehicle with a wider range often settle for “retro” vehicles based on the old “Prius” petrol-electric hybrid principle. With a substantial amount of biofuel in the petrol blend this is just about an affordable option. Most people who work in agriculture or live in rural areas choose non-electric vehicles taking advantage of their right to “red” bio-diesel.

But for most, the fleets of self-drive vehicles scattered across our towns and cities answer their travel needs. With real-time information about the location of vehicles flashed to our communicators, everyone has access to a vehicle meeting their needs for the trip they want to make – a small van for a trip to the store, a small car for running round town or a more spacious vehicle for a day out in the country. And for purely local trips, walking, cycling or the excellent public transport system available in most towns is an adequate solution.

Lest we forget

It's easy to take for granted the progress that we have made in achieving the “low carbon economy” that our forebears aspired to. Extraordinarily, carbon accounting and “footprinting”, now a routine branch of financial accounting, were once seen as the ultimate in state-of-the-art, socially progressive professional activity. What was once the subject of intense political debate and scrutiny has now become a routine administrative and managerial matter. With all the new unprecedented problems that the world faces today – including the legacy of climate change bequeathed to us by our parents and grandparents – it's easy to deride the efforts of those who went before. But give them some sympathy. Like us, they seem to have lived in interesting times.

Jim Skea is Research Director of the UK Energy Research Centre and a member of the UK Committee on Climate Change. This story is told in a personal capacity. Many other versions could have been written.

Jim Skea

Research Director, UK Energy Research Centre

Breakthrough Solutions On The Way To Climate Change Outcomes

“It’s 2050 and the Scottish Government’s climate change targets have been met – how did we do it and what does this brave new world look like?”

Richard Wakeford

Introduction

I have been invited to contribute to this David Hume Institute project as a “policy maker” – perhaps a slightly awkward challenge, since I am not sure policy makers’ personal views should count for much. After all, it will be Ministers’ decisions within the Parliamentary framework that will determine successive governments’ approaches over the next 40 years or so. Ultimately it will be for Ministers now and in the future to account for the “how we did it” in the title of this paper.

Policy makers are, however, responsible to Ministers for sound analysis of the available evidence, and for devising delivery strategies that fit well with other parts of the government programme and are robust against unexpected events. Policy makers in Scotland are doing a lot of that now, not least to work out the options for delivering the Government’s ambitious climate change mitigation target. So, we are a part of the team with Ministers. As a policy maker now it is perhaps more appropriate for me to imagine what the Director General for Environment will ‘inherit’ in 2050, and how they might look back at my work and that of my successors over the years to see how we helped to champion the breakthrough solutions.

Imagining myself in the shoes of my successor, therefore, allow me to look back on three big breakthroughs over the last 40 years or so – breakthroughs that enabled Scotland to become a world leader in climate change mitigation. With other action of different kinds Scotland as a nation *has* achieved the goals for emissions legislated by our Parliament in 2009. But, there is still more to do before our nation can be said to be playing its part in a truly sustainable world. And that has more to do with people in Scotland rather than the governments that have led them.

Key breakthroughs on the path to sustainability and meeting our climate change targets

Looking back from 2050, I see these as being the three big breakthroughs:

1. **The first was the liberation and localisation of energy generation and transmission.** Scotland always had been a nation rich in renewable energy resource, but at the turn of the century “potential” was the word most often used to describe it. Energy companies had started to invest in large scale renewable energy projects – especially wind power. But following the energy price hike of 2008-10, it became clear that high prices were permanent and non-reversible. Businesses of all sizes turned to renewables, responding to price as well as public expectations and the demands of public and corporate customers. And people started to use microrenewables and intelligent devices to turn their homes into small power stations and energy storage locations.

The turning point came when many thousands of small scale hydro projects, modest wind turbines, cheaper solar technology, combined heat-and-power and the like ‘took off’ and began to contribute a significant proportion of the nation’s energy needs. Scotland’s new building regulations helped in this, following an earlier lead by the Greater London Authority which required on-site generation in every large development.

So, regulation was a part of the approach. But what allowed the proliferation of generation possible was a bottom up drive to create **a new sort of local energy grid very different to that then provided by the National Grid under UK regulation.** Creating this new local grid was a huge investment at the time, built up from many small parts (like the world wide web before it) starting with islands like Westray, where whole communities came together in ways that meant energy was generated and used locally.

Our local grids in 2050, incidentally, are quite separate from the sub-sea cables that take our international scale tidal and wind to our export markets in England and across the North Sea. This twin track approach secured Scotland’s prosperity and fuel security from the 2020s.

2. The second breakthrough, achieved in the decade before that, was to put **energy companies in charge of tracking down and eliminating “fuel hungry homes”** leading partnerships with communities, financiers, construction companies, small businesses and local authorities. On the back of dedicated research and analysis of people’s energy behaviours particular to Scotland – homes were improved street by street, community by community, reducing the unit cost for owners and the price paid by residents. New insulation and treatment for draughts was accompanied by helping the public understand how to use home energy controls. The Government supported public-sector landlords in this task, and ensured through regulation that private landlords could not opt out of this exercise. The message was helped by making local property tax higher on fuel-inefficient homes, informed by proper energy assessments along the lines introduced in winter 2008. The public started to see how their properties used fuel and how they could live their lives more energy efficiently. This was Scotland-specific work, taking account of the distribution and nature of the existing building stock that constitutes our built heritage. Retrofitting Georgian and Victorian homes, terraced houses, tenements and exposed croft cottages was a considerable challenge, and we drew heavily on our research base and expert bodies. It took time, but we delivered a Scottish solution to the fuel- inefficient home.

3. **Achieving significant energy gain from natural forces in the sea turned out to be Scotland’s biggest energy step-change of all. The big breakthrough was when the energy companies decided to compete to exceed the targets being set in Edinburgh, London and Brussels. They took the expertise in higher education and research institutes and to add two vital ingredients – investment from major financial institutions based in Scotland, and entrepreneurial business generation.** In the early years of the 21st century, Scotland’s record in new business creation had been nowhere near as impressive as its record in academic achievement. But initiative from the energy companies and a real, concerted government drive to make regulation business friendly and speedier, made a big difference in developing and nurturing Scottish-grown technologies to harness the huge natural resource we had on our very own shores.

Breakthroughs that didn't happen

These three big breakthroughs and other action helped achieve the statutory target for reducing greenhouse gas emissions set in 2009. But how does that leave Scotland in 2050? For example, has our leadership as a nation of increasing international influence inspired other nations to follow suit on the scale needed to bring global climate change back within safe bounds?

Today, in 2050, people have not relinquished the huge personal mobility that the motor car still provides, by comparison with inflexible public transport. They have not needed to, because shared electric cars powered by our renewable energy sources are now the norm. Based on technology developments reaching the mainstream during the 2020's, these provided us with the mobility we needed within better-functioning local communities – using the local grid and renewable energy for plug-in functionality. We fly a lot less, of course, since the costs increased significantly, first to reflect increasing oil prices and then the full environmental cost. Community led initiatives also led to very high efficiency buildings everywhere. So, carbon emissions have been reduced by wiser transport and housing decisions.

Other areas have not seen the same revolution. We were not helped at the start by the perverse nature of Common Agricultural Policy measures that made it more difficult to transform poor quality agricultural land into timber growing – needed to achieve the goal of 25% forest cover. So, in agriculture and land use we came late to an agenda for change. Farmers certainly responded to the opportunities to change practices to reduce their use of energy and fertilisers rich in fossil fuel. We worked out where and how to stabilise peat soils. Rural businesses became big providers of local energy through biogas, and tree planting. Much of the arable sector has now worked out the technology needed for low till cultivation. Scotland remains a globally renowned producer of grass fed livestock, of more value in a world where good grass growing conditions are increasingly rare, offsetting the cost of the associated methane emissions against other progress we have made.

But if our production is now much more emissions friendly, our consumption of goods imported to Scotland has remained high. Even for consumers wanting to make them, wise choices have been difficult given the absence of reliable information about the carbon content of imported goods and the frustration of constantly looking for information on complex informative labels. There has never been sufficient understanding of the need to reduce our resource consumption to a one planet pace for politicians to be able to legislate for personal carbon allowances.

The point here is that there have always been limits to what governments can do. Public opinion is crucial in determining how public money is to be spent, how taxes are to be applied and what regulations will be enforceable. Parliament might, for example, make a law to require double glazed windows but a big change in people's mindsets is needed before society will accept prosecutions for leaving them open with the heating on. Action on climate change in Scotland needed more than just a change in the law and the way successive governments spent taxes. It needed a change in people's mindsets.

Changing mindsets has always been incredibly difficult. Despite public campaigns from the 1990s on, Scotland's population took a long time to accept the need to eat more healthily and to take enough exercise – far longer than expected under successive governments' diet action plans. Greener Scotland campaigns, especially involving action at the community level, also delivered progress, but not on the scale needed. Some in society were ready to change their behaviours most readily, and could afford to do so. But others looked at less committed nations around the world and wondered whether reducing carbon emissions in Scotland was really worth the sacrifice. And newly needy sector - the carbon-disadvantaged – struggled to meet the cost of the embedded carbon properly factored into the price of things, but equally struggled to afford to become carbon efficient. The challenges of 2010 have evolved into new challenges in 2050. With hindsight, we were driven too long by a failure to reconcile the twin goals of GDP growth and green progress in an increasingly turbulent world.

The global population rise to 9 billion was long predicted, but like many other developed countries, we did not predict just how the pressures on food supply and energy would impact on world security and our lives. Growth in China, India and other smaller emerging nations on the world's economy challenged us much more than we imagined to find our niche in the world, especially given the distribution of the remaining fossil fuels among relatively few countries, with huge power as a result. At least we earned our own energy security, which has helped us to sustain the high quality public services our citizens expected, through our leadership in energy and environmental businesses. Strong growth came from entrepreneurial exploitation of the knowledge in our higher education and research sectors, long recognised as 'seed beds' for energy technologies.

We had hoped that such strong and sustainable economic growth would help us to become a nation of wellbeing, enjoying extended healthy lifespans, where our basic needs were comfortably met and our children faced their future with confidence. We had hoped to achieve a 'zero waste' Scottish society, where through steady support of recognising and rewarding environment-benefitting behaviours, people in Scotland came to consume in a radically different way than when our climate change targets were set back in 2009. We had hoped for many more of us to live in places designed or adapted to be health-promoting, cycling and using public transport more.

Certainly, in 2050 one quarter of our population is now over 65, and 40% of those are now over 80 years of age (requiring younger people to create the wealth to support them). We also produce less waste and live in more sustainable communities. We do use much less energy directly; and most of that comes from friendly sources. But, as consumers we don't do enough to discriminate against other goods with high embedded carbon. Our wealth from new energy related industries has in fact enabled us to continue to consume products from all round the world.

Even if consumers were more minded to discriminate, world trade rules don't help. Nations less committed to climate change action and worried about the impact on their economies prevented the World Trade Organisation from requiring businesses to label goods for their emissions impact. For too long, reliance on GDP as the measure of success in the developed world compounded the problem, in that prices just didn't reflect the 'whole life cycle' cost of production on the world's natural capital; and markets therefore failed to include the signals that would have helped change consumption patterns in the way the world needed.

Consumers needed to take more responsibility for the carbon associated with the goods they buy and use; but how could they, without pricing signals and proper information? Carbon labelling got off to a rough start in 2010 (with work from the Manchester Business School) but the journey towards ‘carbon literacy’ has been slow, and it took some time for this greener priority to come alongside the established literacy and numeracy priorities of the school curriculum. What started out as an apparently simple ‘greener’ objective, turned into rather a difficult and tortuous journey for policy makers. Each DG Environment since 2010 has faced their own challenges genuinely to mainstream ‘greener’.

It’s worth dwelling on public attitudes as a driver of progress. The government in Scotland invested heavily in spreading knowledge at the start of the century through various campaigns. This was partly because, before independence, the Government had few fiscal tools available. But even with those tools, governments found it hard to make progress without public opinion strongly in support. They needed to demonstrate, literally, how much better ‘Sustainable economic growth’ could be. Initiatives such as public awareness campaigns, eco-schools, the early ‘eco-demo-towns’ and government action on issues like procurement all served to demonstrate that economic growth could be more sustainable – reflecting environmental and social equity.

In conclusion

In 2050, we are at last realising what it means for Scotland to ‘grow sustainably’ and people are now much more engaged, informed and carbon-wise. It has been a tougher journey than many policy makers imagined.

The world has changed beyond recognition. Food and energy, population growth, tackling poverty and increased urbanisation, mass migration as a result of the increasing scale of weather based disasters, rising sea levels, new diseases and the increased heat in some parts of the world – all these things have had consequences for Scotland. We have responded by making the climate change challenge local, and increasingly personal. People’s mindsets have changed, but not as fast as was originally expected. Our economy increasingly reflects the environmental leadership found nationally and locally throughout the nation. That we have been green leaders internationally is a matter of national pride.

By adopting a mindset that EU and other targets were there to be exceeded, not just met, Scotland started to ‘set the pace’ for action. The challenge to policy-makers facing an increasing pressing climate challenge, was to take stock, apply the science, identify the opportunities to be bold and to help Ministers move policy forward with vision and conviction – both incrementally and with breakthroughs. The 2007 Government’s commitment to make economic growth sustainable for the benefit of all in Scotland was itself one big breakthrough that brought us a better world today in 2050. But people needed to be more committed too, and follow through with more action themselves. How much is that the responsibility of politicians – to lead the people or respect the existing will of the people? That’s a critical question for any policy maker.

Richard Wakeford

Director General, Environment, The Scottish Government (personal views)

Well we made it then!
David C Watt

When our climate change targets were set back in 2008 not many people believed we would meet them and certainly few would have suggested how we did eventually meet them.

Back then everyone saw the car as the devil and public transport as the saviour, while large wind power sites were the latest vogue and nuclear power was never to be part of the energy mix. Individuals were very worried about their own fuel costs regardless of whether it was for moving their car or warming their house. Some businesses too could not see how they would be sustainable faced with rising and it seemed unstoppable costs.

There was an air of gloom and despondency across what was then seen as the “developed” world as China and India started to appear as major industrial players. Indeed many saw it as the start of the downfall of capitalism and the demise of the market mechanism which they felt would change our way of life quite fundamentally. It was seen by many as a cue for punitive taxes on businesses who were seen as a major part of the problem.

The energy companies themselves were particular public targets of annoyance as many vented their anger on them. Business and profit in this area was bad – as was the reputation of everyone involved.

Sitting here in 2050 this all seems like ancient and inaccurate history but we arrived at a successful climate change outcome in Scotland in some ways that perhaps many would not have foreseen. Not really surprising because the human race has never been very good at forecasting its future or that of the planet. It probably is to be expected because no one in 1950 foresaw the technological or medical advances of the next 50 years or the population changes which thereafter fundamentally affected this country.

So what were the key factors and steps in successfully achieving the targets we set ourselves?

Well first of all we began to realise that the economy – and the firms which make it up - was not the problem but the crucial solution – that the private sector was in fact the main mover in meeting the targets. The market driven economy was the saviour of our planet – some could argue!

The state played an early role when after many years of complacency and sloth in the early 2010’s it managed to establish a national improvement agency to replace what had previously been known as the planning service, and gave it some clear focus on bringing Scotland up to World Class in terms of getting projects approved and completed quickly and efficiently. The old service had just before its demise eventually succeeded in processing the backlog of over 5,000 individual power micro-generation schemes. Going into 2009 there were 2,550 people waiting for approval for domestic wind turbines alone.

Vital here also to driving all these schemes forward was the new – primarily SME - industry which grew up led by companies like Windsave to design, manufacture and install domestic wind turbines, heat pumps, solar panels as well as fuel efficient and alternative fuel boilers.

With that problem eventually moving forward if not completely solved, the larger schemes of wind and wave power, along with clean coal and carbon sequestration were then taken forward by the improvement agency and pushed through more quickly. Perhaps this was the time when the government at last seemed to realise its targets would not be met through relying on the current structures and speed of operation.

Larger projects again were founded on Scottish innovation, manufacturing and implementation and once again in the 21st Century this country really did lead in Europe, if not the world, in developing the ideas and the technology to make carbon efficient energy production turn from dream to reality.

The national grid was extended but matched into a key focus on the localised provision of power especially through micro generation. An undersea grid was developed in the North Sea and one will soon follow on the West coast. Fuel cell technology has allowed storage of electricity so peak demands can be catered for should the wind not blow or there be any other fluctuations in supply.

This has been coupled by a 25% real cut in usage in the domestic market brought about through a combination of price rises and improved domestic energy efficiency which meant most domestic consumers had to contribute something. This was matched by a general belief that we should each do something about global warming and cut our individual carbon emissions.

The same rising costs have forced industries large and small to look at their demand for energy and do everything in their power to dramatically cut all but essential use. They have also been enormously innovative in reforming their processes and methods to ensure top levels of fuel efficiency; and where this cannot be reduced to minimum then they have developed their own sources of renewable production.

This rise in costs and the drive for efficiency as well as savings on carbon taxes across business has also driven some quite different working patterns across the country – again affecting all sizes of business.

The move towards flexible and remote working had begun to gather pace in the 2000's but these drivers – carbon and cost – produced a quite dramatic alteration of company strategies. Big offices began to shrink and local became good.

Companies who had previously been limited by the worries over work getting down, the lack of supervision and the lack of human interaction were pushed to overcome these reservations and home and remote working has become the norm.

The implementation of sophisticated IT programmes was accelerated to facilitate more internet purchasing, more remote working and more localised delivery of business. Telephone systems have largely been superseded by internet linked systems with all main town centres being Wi-Fi networked - landlines are a thing of the past.

Localised delivery and focus for some bigger companies – driven by a need to be accessible to customers without excessive travel has meant a reversal of some of the centralisation seen during the late 1900's and the early 2000's. A trend that some thought would never stop was turned around by economic necessity to cut travel costs and CO2 emissions which became increasingly unpopular with both stakeholders and customers alike.

More carbon friendly cars which developed very quickly from 2010 did have a big impact and due to the ever increasing cost of petrol and diesel these were adopted quickly. Companies like BMW were at the forefront of this technological revolution – probably the biggest in the automotive industry since the internal combustion engine was invented. Hydrogen power and fuel cells meant that by the 2020's the car had changed out of all recognition, and was effectively not using carbon as it was used. New design and different materials even lessened the impact of its construction and assembly, whilst manufacturers developed a major offsetting programme for the residue – effectively resulting in a carbon neutral car!

Public transport was also expanded and became significantly more fuel efficient through engine design, sleeker vehicles, and lower fares and increased occupancy accompanied by better co-ordination of the various forms of transport. It has had a sizeable effect but not perhaps as much as some would have expected, because our carbon neutral car remains the transport mechanism of choice.

New high speed rail services between the major cities of the UK – finally completed in 2030 have brought about the desired reduction – almost disappearance of domestic air services. International flights are now all offset by law by the passengers and in any case the engines are so efficient that their environmental impact is less than one hundredth of what it was at the turn of the century.

Interestingly that trend towards carbon substitution schemes, set by the automotive industry, was followed by a wide range of businesses – from the little to the very large. They at the same time developed a strong social conscience and started to get closely involved in starting or supporting environmental initiatives. These were designed to help counteract any climate change impact of their organisation's activities.

A great example of that is the Global Trees initiative to plant trees to bring back the oxygen to our atmosphere and help eat up the carbon we produce. The idea is simple buy an appropriate number of trees to counteract for long haul flights, for example.

Some say that such steps are merely cynical ploys to impress customers – others believe it was a genuine human reaction of business leaders.

It has always been thought that young people needed lots of education to push forward innovation and change but there has been an almost opposite paradigm in the case of climate change where the future generations have been educating and driving the older generation – with arguably less to lose – to do something to safeguard the planet for the years and centuries to come. The young have been the ones who want things done urgently.

One of the biggest surprises for many must have been the fact that the private sector led the charge to cut greenhouse gases and did not have to be penalised through taxation or legislated into action. The dual factors of market forces and business opportunities were the biggest drivers; linked for many by a genuine desire to take action to save our planet.

So in summary and perhaps not really that surprisingly we have achieved our targets – which were seen as ambitious when originally set – due to government taking key structural and organisational culture moves, business being creative, inventive and innovative, and finally individuals reacting positively partly because of push and partly pull. There is a real nationwide desire to leave the planet well protected for future generations to come.

We did it then and not only helped increase the life of the planet but contrary to expectations also improved our quality of life.

David C Watt

Director IoD Scotland (personal view)

About the Children's Climate Change Project 2008

This year, Scotland will consider significant legislation on climate change. Children, with arguably the biggest stake in what is decided, have an important role to play in this debate. With that in mind, Children in Scotland and WWF Scotland have brought together a project with the Children's Parliament and support from Scottish Government and Scottish Commissioner for Children and Young People to enable children, from across Scotland, to contribute to the debate about climate change and to have their views heard. A group of children aged 9-14 yrs were provided with access to information and support to enable them to discuss and debate their thinking on climate change. They were offered an opportunity to articulate their conclusions and share outputs, including a large mural, with a wider audience of adults, including key players in the climate change debate, politicians and the media. Their conclusions will be fed into the debate on climate change and Scottish climate change legislation through 2008 and beyond.

www.wwfscotland.org.uk/climate

About the Children's Parliament

The Children's Parliament introduces children to a world of ideas and provides opportunities for critical thinking and direct engagement in mainstream decision making processes. Through creative and participative approaches, children develop their self confidence and self esteem and begin to take up the challenge of becoming informed and genuinely engaged citizens who help improve and shape the communities they live in.

www.childrensparliament.org.uk <<http://www.childrensparliament.org.uk/>>

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