Need for a new strategy and policy on infrastructure

Finally, I would add a note of caution about the implications for investment and the recovery of fixed costs in gas infrastructure. If the EU is serious about its 80+ per cent emissions reduction by 2050, the total EU gas market could be significantly smaller than at present, and it is in any case unlikely to grow by much. Yet investment timescales in gas, especially in gas infrastructure, are very long and investment may well be needed in order for gas to play a bridging role in the near to medium term in certain regions. This has two implications: one for industry and the other for policy makers.

'IF THE EU IS SERIOUS ABOUT ITS 80+ PER CENT EMISSIONS REDUCTION BY 2050, THE TOTAL EU GAS MARKET COULD BE SIGNIFICANTLY SMALLER THAN AT PRESENT.'

The gas industry needs to develop a coherent long-term strategy to reflect the likelihood of stranded network assets in certain regions. On the one hand, if the assets are fully amortized, they can be abandoned; what matters are forward-looking costs. On the other hand, it is worth considering alternative uses of pipeline, storage, and LNG infrastructure. Some companies are already thinking about this; for example, converting renewables into hydrogen gas, which can then be transported, stored, and blended with natural gas in existing infrastructure. If CCS becomes more significant, it may also be possible to use the gas infrastructure to transport and store CO_2, although this will depend on location and geology. More generally, the gas industry should be thinking about the longer-term uses of its network in a low-carbon world. As European gas production declines and if gas consumption also declines, infrastructure could be the industry's main asset.

It is also important for the industry to press effectively for *a clear public policy* to help investors decide whether to proceed with new investment in infrastructure. For example, the Spanish gas industry argues that due to its significant LNG assets, Spain could play a key role in providing continuity of European supply. Expanding the capacity of gas pipeline infrastructure between Spain and France could help bolster supply to France and allow other pipeline supplies to be diverted further eastwards.

However, for additional Spanish gas exports to reach central European markets would require additional infrastructure investment in France, as well as the interconnector investment between Spain and France. It may be less expensive to transport LNG to northern Europe than to build new interconnectors and additional pipelines through France. The question is therefore whether these new infrastructure investments (interconnectors and national grids) are economically justified, and who would bear the costs if the assets lost value due to the lack of utilization. This requires careful and independent study. But it also requires a clear statement of European policy with respect to the future role of natural gas in the EU's long-term decarbonization and energy strategy, along with measures to realize that policy.

In conclusion, for natural gas to support decarbonization in the short to medium term requires urgent policy support and planning, both at EU and national levels. In the longer term, in the absence of economically viable technologies to capture and use CO_2 emissions, the future for natural gas must be in question if the EU is serious about moving to a low-carbon energy system. Given the very long lead times needed for infrastructure investment, and the need to reduce emissions over the next two decades, a clearer strategy for the role of gas and how it fits into the transition needs to be developed to underpin investment.

Nuclear after Paris: any clearer?

Malcolm Grimston

One might have expected that the Paris Conference of Parties meeting (COP21) on climate change in December of last year might have placed a particular focus on nuclear power. For some years France has generated a higher proportion of its power from nuclear than any other country. This French version of Germany's Energiewende – tournant énergétique perhaps? – came along a quarter of a century before Germany's and, if judged in carbon reduction terms at least, was notably more successful. In comparison with its neighbour, Germany's energy and environmental policy (set out in the 1991 and 2000 Renewable Energy Acts), had had limited success in reducing greenhouse gas emissions, even before the 2011 post-Fukushima decision to close its nuclear plants.

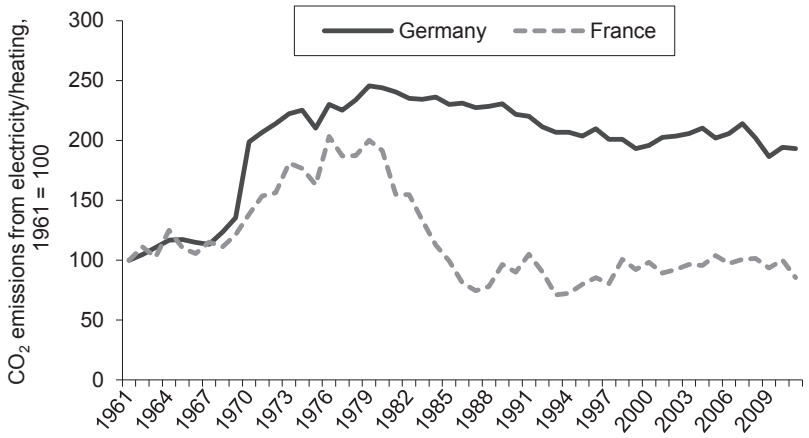
Releases from electricity and heating followed the same path in France and Germany until about 1980, after which

'…THE GROWING FRENCH NUCLEAR FLEET BROUGHT EMISSIONS DOWN TO LEVELS THAT WERE EFFECTIVELY THE SAME AS … THOSE OF THE EARLY 1960S.'

the growing French nuclear fleet brought emissions down to levels that were effectively the same as, or slightly below, those of the early 1960s. German emissions remained twice their level in 1961, falling less than 1.5 per cent in the decade after the 2000 Act. Emissions rose in four of the five years following Germany's decision to exit from nuclear: even during the warm summer of 2014, emissions failed to return to 2011 levels.

France led the 'dash for nuclear' (in part a response to the oil shocks of 1973 and 1979) from 1975 to 1995. For the only time in history so far, since the start of the industrial revolution, the global proportion of primary energy produced from non-fossil fuels increased significantly, from around 6 per cent in 1975 to 13 per cent in 1995; it has stubbornly stayed at this level despite the growth in renewables.

In the two peak years for nuclear installation so far – 1984 and 1985 – some 64,000 MW of nuclear capacity came on line, capable of producing around 500 TWh of power per year at a reasonable level of performance. Given today's global power demand (around 24,000 TWh), sustaining that rate of deployment for the following 30 years, all else being equal, would have resulted in a world that obtained well over half of its electricity from non-fossil sources by now, as opposed to barely one third.



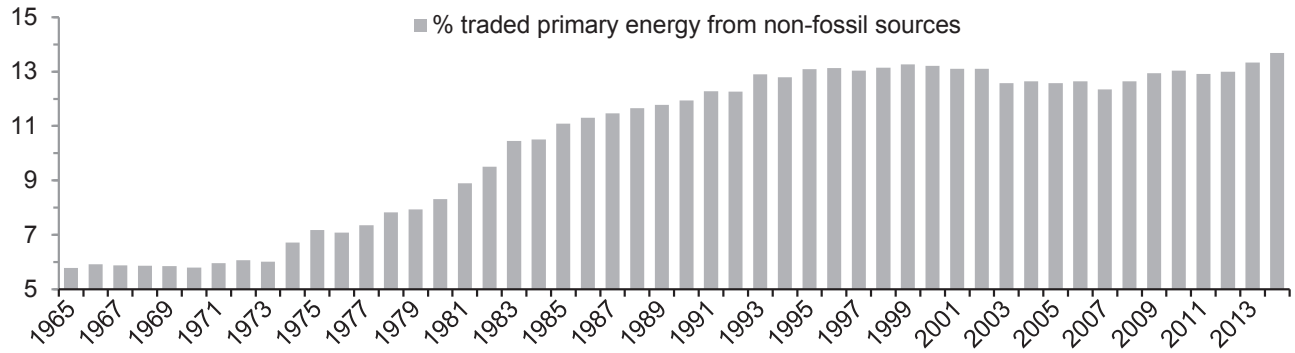
CO_2 emissions from electricity and heating, Germany and France (1961 = 100)

Source: 'Climate change knowledge portal', World Bank, 2014

Antinuclear activists were nonetheless successful at the key Kyoto COP meeting in 1997 (COP3) in excluding nuclear power from the 'Kyoto' mechanisms, notably the Clean Development Mechanism. An illustrative example of antinuclear tactics came in 2009 from the Worldwide Fund for Nature (WWF). In its 2009 G8 Climate Scorecards, the organization faced a difficulty – calculations based on actual greenhouse gas emissions from energy use kept placing countries like France and Sweden, with their large nuclear programmes, at the top in terms of reducing greenhouse gas emissions. WWF's response was an object lesson in Big Green science.

> *'WWF does not consider nuclear power to be a viable policy option … To reflect this, a policy approach that favours the use of nuclear power was assessed by assuming that electricity from nuclear energy was produced with gas.'*

Sure enough, by redefining 'very large volumes of carbon dioxide emissions' to include 'minuscule levels of radioactive releases' in such an



Percentage of global primary energy from non-fossil sources, 1965–2014

BP Statistical Review of World Energy, 2015

'ANTINUCLEAR ACTIVISTS WERE NONETHELESS SUCCESSFUL AT THE KEY KYOTO COP MEETING IN 1997 IN EXCLUDING NUCLEAR POWER FROM THE "KYOTO" MECHANISMS…'

arbitrary way WWF was able to give the impression that nuclear power was not a particularly effective way of reducing greenhouse gas emissions. (*G8 Climate Scorecards,* WWF-Allianz, July 2009).

In the early days of the Paris summit, in the words of one commentator, nuclear power 'struggled to find its voice'. Things warmed up somewhat when four of the world's top climate scientists (Ken Caldeira, Carnegie Institute; James Hansen, Columbia University, credited with getting climate change onto the US political agenda in 1988; Kerry Emanuel, MIT; and Tom Wigley, University of Adelaide) delivered a performing version of their celebrated 2013 letter calling on environmentalists to think again on the nuclear issue – something which increasing numbers have duly done. As Caldeira said:

> *'The climate doesn't care whether electricity comes from a wind turbine or a nuclear reactor. The climate just cares about carbon. I've come to see now that the magnitude of the problem is so great that we can't afford to leave technologies unused that can potentially help.'*

This did not go down well in all quarters. One Naomi Oreskes, a history professor, argued that anyone proposing deviation from a prescribed 100 per cent renewable approach should be classed a 'climate denier' – perhaps a harsh verdict on Hansen and his colleagues given their record ('There is a new form of climate denialism to look out for', *Guardian*, 16 December 2015). Oreskes seems to depend heavily on work by Mark Jacobson from Stanford, who claims that 139 countries can generate all the energy they need from wind, solar, and water power technologies by 2050. Like all such claims, they assume startling reductions in energy use – by 43 per cent in the UK, 36 per cent in China, 43 per cent in India. (Current World Energy Council estimates suggest a doubling in Chinese energy use and a 150 per cent increase in India's by 2035.) Historically, however, improvements in energy efficiency have often been associated with growth in energy demand, by stimulating demand.

The reasoning behind the 'energy efficiency argument' seems to be along these lines: if we had not developed the light bulb – first incandescent and more recently LED – then if viewed from space the earth would still be producing just as much artificial light but it would be coming largely from candles. On this assumption the development of electric lighting has indeed cut energy use enormously. The development of the jet engine has slashed energy use for long haul air travel because otherwise we would be undertaking some 15 billion passenger miles each year by turboprop or maybe even Gypsy Moth. One would need a lot of persuading to bet the planet and secure power supplies on such an argument – even the IPCC and the European Union now acknowledge the importance of these 'rebound effects'. It certainly cannot be claimed to be so self-evident that anyone who remains unconvinced can be regarded as 'denying' anything – except perhaps the value of blinkered thinking.

The justification for treating renewables more favourably than nuclear power has usually involved some invocation of the supposed 'maturity' of nuclear technology against the 'emergent' nature of the renewables. This is a peculiar argument. The ironically named 'new' renewables have been around almost as long as electricity as an energy vector. Edison opened his Pearl Street power station in 1882; the first electricity from solar photovoltaics was generated in 1884; from wind in 1887; from geothermal in 1904; from wave in 1910. Denmark, for example, had 30 MW of wind-generated electricity capacity by 1900. The dominant (and ultimately unsustainable) model of electricity generation in the late nineteenth and early twentieth centuries – localized small-scale renewable production embedded within the demand network – was swept away when national supergrids emerged from the 1920s and 1930s onward. Suddenly consumers could have electricity when they wanted it without the vast cost of battery storage. Demand soared. Hydro (almost) held its own against fossil fuels, as its power was generally available when it was needed, but the story of the middle years of the twentieth century was of fossil fuels, with all the associated geopolitical and environmental challenges they bring. The first nuclear-generated electricity did not come along until 1951.

Growing divisions within the environmental community may have been a factor in the change of tone in the agreement reached in Paris. The 32 page final document marks a significant shift away from a prescriptive approach driven by an imperative to promote certain technologies rather than to reduce carbon emissions. There is a single reference to:

> *'the need to promote universal access to sustainable energy in developing countries, in particular in Africa, through the enhanced deployment of renewable energy'*

but otherwise neither of the words 'nuclear' nor 'renewable' is to be

found. So in principle countries are free to approach their carbon reduction programmes in whatever way they see fit. For the relatively few players for whom reduction in climate change emissions is the top priority this will be welcome.

But it is a far cry from this move towards treating nuclear and renewables more equitably to assuming that a major nuclear revival is just round the corner. Especially in the five years since Fukushima, public perceptions and political opposition have remained an obstacle in several countries, most notably perhaps in Germany and Japan but also in, for example Italy, which rejected a return to nuclear in a 2011 referendum. (Elsewhere, including the USA, Canada, Scandinavia, eastern and central Europe, much of Asia–Pacific, and the UK, this is much less the case.) Political and public concerns can be damaging to nuclear prospects through direct political decisions to curtail the lives of reactors, by preventing their return to service, or by introducing tighter regulation, which can increase costs.

'IT IS COST THAT IS SINKING NUCLEAR POWER IN THE "OLD" NUCLEAR NATIONS OF WESTERN EUROPE AND NORTH AMERICA.'

And it is cost that is sinking nuclear power in the 'old' nuclear nations of western Europe and North America. Around the turn of the century the US Department of Energy was suggesting that new nuclear capacity should cost about US$1,500 per kW for the first-of-a-kind (£1,400 today, inflation corrected) and US$1,200 per kW for a programme of four or more. Even excluding financing costs, Hinkley Point C is expected to come in at around £16 billion for 3.3 GW, which works out at around £5,000 per kW. The new reactor at Flamanville in Normandy is currently six years late and around €7.2 billion over budget; Olkiluoto-3 in Finland is expected to be 10 years behind schedule and €5.5 billion over budget.

The UK government has done as much as could reasonably be expected to transfer a significant proportion of the inherent economic risk involved in nuclear investment from the investor to the electricity consumer. Though fuel costs are lower in nuclear stations than in Combined Cycle Gas Turbines, CCGT is much quicker and cheaper to build, and so is much less risky in a competitive market. Potential nuclear investors will require some very good reason to think that power prices will remain sufficiently high for several decades, to repay the initial investment and deliver an appropriate rate of return.

In centrally planned electricity systems this is reasonably straightforward, at least in theory; the plant is owned or operated by a monopolistic supplier with de facto lifetime contracts for its output, so any excess costs can be passed on to captive customers. Within a broadly competitive market framework, however, the risks associated with purely 'merchant' nuclear plants have proved too great. To stand any chance of attracting investment, then, government has to offer some long-term guarantees over the price at which the electrical output can be sold – in the UK this has taken the form of a 'strike price' of £92.50 per MWh (index linked from 2012 prices) which will run for the first 35 years of the plant's operation, coupled with loan guarantees on part of the initial investment. Yet despite these inducements, despite China offering to take a one-third stake in the project, the Final Investment Decision on Hinkley Point C has been delayed and delayed since EDF Chief Executive Vincent de Rivaz's statement in 2007 that:

> *'EDF will turn on its first nuclear plant in Britain before Christmas 2017 because it will be the right time.'*

The dash for nuclear has not entirely evaporated – China has plans to triple its nuclear capacity to 58 GW by 2020 and there are ambitious plans in India, for example, with several countries talking about entering the technology for the first time. If China's record for building plants within a reasonable budget and to time can be exported to other countries, then nuclear power's prospects would look considerably brighter. Attention is also turning to new approaches, the so called SMRs (Small Modular Reactors). In principle, SMRs could be built as one or two units or as modules in a bigger complex. The simplification of design, and increased reliance on passive rather than engineered safety systems, could significantly reduce the cost of nuclear plants without any negative implications for safety or plant reliability: such plants would rely on naturally occurring phenomena such as gravity, natural circulation, and condensation, guaranteeing (it is claimed) safe shutdown of the plant even in the highly unlikely event of an accident. The loss of economies of scale enjoyed by large units may, at least to an extent, be offset by the series economies which come from building larger numbers of identical smaller units. A bank of fifteen 100 MW units would be more flexible than a single 1,500 MW reactor, there being the option of switching some units off to follow load rather than trying to vary the output of single large units, which tend to be regarded as rather inflexible. Several SMRs are now operating across the world. But it would be a mistake to presume (in any technical field) that attractive concepts on paper can easily be translated into a large commercial programme.

At the heart of the power problem in the market economies lies a

'THE DASH FOR NUCLEAR HAS NOT ENTIRELY EVAPORATED.'

confusion that is still not resolved. Is electricity basically a commodity or is it a social/industrial service? If the former, then government's role should involve: setting up a stable market that corrects for externalities, notably in the environmental field perhaps through carbon taxes or tradable emission permits, preventing oligopoly, and allowing the market to make the investment it sees fit. If it is the latter, then government is effectively the guarantor of last resort. It might use market forces to help deliver on its goals, for example by offering competitive tenders for power station construction and operation, but ultimately it remains responsible for the fuel mix, the environmental outputs, and the security of supply. At present, it can be argued, we have the worst of both worlds. Government (or the power consumer) is in effect paying rates of return to the private sector to persuade private, or rather non-UK government owned, companies, to carry out public policy. Even what now look like very generous terms for Hinkley Point C have so far failed to persuade the French to make the investment required, even with Chinese backing.

So, if the government has that ultimate responsibility – and who can imagine any government of the day getting out unscathed if we could not power our hospitals, petrol pumps, street lighting, water distribution network, mobile communications and so on? – is it time for government to take back unequivocally the responsibility for constructing sufficient low-carbon generating capacity to face the new challenges? Once built, the plants could be sold on or franchised out, since markets do seem good at operating existing assets efficiently. Public sector rates of return would reduce the costs of the capital-intensive electricity sources significantly.

It is not, of course, certain that government would be any more reliable as a long-term partner to nuclear construction companies than the current short-term market is. It took a year to persuade the European Commission to allow the Hinkley Point C deal and appeals are still going through the system – in the absence of Brexit it would be a very difficult conversation that would lead to the UK regaining powers over all new plant construction. But the Hinkley C saga shows that the present approach does not work: the market simply cannot send firm signals to invest, even with the high levels of support now on offer. Unless this barrier can be overcome it may prove academic whether nuclear power has indeed come in from the cold as far as the fight against climate change is concerned.

US climate policy in a post-Paris context

Sarah O. Ladislaw

The USA's goal for the UN climate negotiations in Paris last December was to secure broad and meaningful participation from member countries and establish a long-term, durable framework for future actions to cope with a changing climate. Supporters of the Paris Climate Agreement tout its success for delivering on that goal, mobilizing emissions reduction efforts, and sending signals to catalyse additional finance and investment. However, the Agreement is also criticized for falling short of the action necessary to secure the 2 °C temperature rise limit and for lacking strong enforcement mechanisms. Going forward, the objective is to deliver on the commitments secured in Paris and find ways to enable even deeper emissions reductions and more robust adaptation measures that will be necessary to mitigate the climate risks.

'THE FUTURE OF US CLIMATE POLICY WILL BE DETERMINED BY THE OUTCOME OF THE 2016 PRESIDENTIAL ELECTION CYCLE.'

So what is the likely path forward for US climate policy in a post-Paris context? Many have argued that the future of US climate policy will be determined by the outcome of the 2016 presidential election cycle. This belief is supported by two underlying factors.

- First, in order for the USA to meet its near and medium-term emissions reduction targets, existing policy and regulatory measures must not only go forward, but additional emissions reduction efforts will be required. Moreover, meeting longer-term climate objectives will require the next administration to lay the groundwork for even more ambitious emission reduction.
- Second, Republican and Democratic presidential candidates have vastly different climate policies that would, if implemented, lead to different energy sector and emissions outcomes.

US targets are tough to reach, yet not enough

In its Intended Nationally Determined Contribution (INDC) submission, the