

CHAPTER 13

NUCLEAR POWER: THE IMPOSSIBLE CONSENSUS

The EU needs to spend at least 30 times more on nuclear waste management research.

Loyola de Palacio, European energy commissioner, 2003

Earlier, in Chapter 2, nuclear power was rated as having a high potential for EU collective action. This does not necessarily mean a common policy, which would be impossible when 13 member states do not have, and some of those do not want, nuclear power. It is rather the EU's potential ability to make nuclear power development easier for member states than it would be if they did not belong to the Union. As mentioned in Chapter 2, nuclear power's EU potential is rated at least as high as that of energy market policy, because it was given a complete institutional framework right from the start with the Euratom treaty of 1957.

But, in spite of Euratom, all key nuclear power decisions are national and are likely to stay so for a long time. Nor has a lavish EU nuclear research programme solved the problems that most worry Europeans about atomic power, such as final disposal of radioactive waste. So it is easier to argue that nuclear power has contributed more to Europe than Europe has to nuclear power.

The past year, 2007–8, has seen a modest revival of EU-level interest in nuclear power. The Commission has formed new groups of national regulators, officials, executives and researchers to discuss how to improve safety and radioactive waste management, how to harmonize national rules in these areas with a view to reducing the differing national standards that new reactors would have to meet across Europe, and how to make regulation and risk in nuclear power more comprehensible and hopefully acceptable to mostly sceptical European publics.

Such efforts are appropriate. For nuclear reactors still generate a third of total electricity in the EU. This contributes to Europe's energy security; though natural uranium is almost entirely imported, it is a small part of nuclear power's total cost and its enrichment into reactor fuel is mostly carried out within the EU. It contributes even more to the fight against climate change. 'Continued use of nuclear energy in the EU is almost certainly going to be necessary to attain the policy goals in climate change and security of supply', said the International Energy Agency in its 2008 report on EU energy policy. The EU's 152 reactors, more than in any other region of the world, provide two thirds of Europe's carbon dioxide-free power. As such they draw indirect financial benefit from not needing the carbon emission permits now required of electricity generators using fossil fuels. So the perspective for nuclear power in Europe should be brighter.

Yet nuclear power will be lucky to maintain its one-third share of generation in the future. The average age of the EU's 152 reactors is around 25 years. This would not matter – reactors are typically designed for a 40-year working life that these days can be safely extended by a few years – if a reasonable rate of replacements was being planned.

At the time of writing, only two reactors, one in Finland and one in France, were being built inside the EU. More countries are considering building new reactors. They include the three new member states: Lithuania, Slovakia, and Bulgaria, which are being obliged to shut down, as a condition of their entry into the EU, Soviet-era reactors judged to be unsafe. But there is interest elsewhere in Eastern and Central Europe, a region where green political parties are weak and where economic factors still tend to prevail over environmental ones, in expanding nuclear power. Romania and the Czech Republic plan to expand their atomic power programmes, while Estonia, Latvia and Poland are discussing participation in a new Lithuanian reactor.

In Britain, the first country in Europe to open a power reactor, the Labour government has decided in favour of replacing its existing reactor fleet (the oldest in Europe with an average age of 30 years), but is leaving to the market the question of how and who should do this. Again, at the time of writing,

the UK government had yet to entice any company into a firm contract to build new reactors. In Italy, the first country in Europe to abandon its nuclear programme (after a 1987 referendum with a narrow No majority vote against nuclear power), the government of Silvio Berlusconi, re-elected in 2008, announced it would seek to reintroduce nuclear generation. This will not prove simple.

Having shut down its programme, any government in Italy may feel the lack of local support for nuclear power surrounding reactors that are still operating, though there is still some residual employment around old reactors to carry out decommissioning. For it is an observable fact, virtually everywhere, that the strongest backing for nuclear power comes from those most immediately living and working with it; this is why the easiest place to put a new reactor is next to an old one. Any such difficulty in restarting nuclear power from scratch may give pause to those other EU states that have said they will phase out nuclear power by not replacing their existing reactors. Germany, Spain and Sweden are still on course to do this eventually, although there is a debate in each of these countries about the wisdom of this. Belgium announced in spring 2008 that it was reviewing its gradual rundown of nuclear power.

So the situation differs country by country, and it hard to see how things could be otherwise, given present perceptions of the costs and benefit of nuclear power. The memory of the 1986 Chernobyl reactor accident in neighbouring Ukraine is still too recent, and the prospect of catastrophic climate change, thankfully, still too remote, for EU states to agree – as they have on renewables – that nuclear power should form a *common* part of their energy mix.

Moreover, different European societies cope differently with the challenges of nuclear power. For France, the military use of the atom is not seen as original sin tainting civil nuclear; indeed its nuclear arsenal, the *force de frappe*, is a source of national pride. France, too, took very seriously the energy insecurity it felt during the 1973–4 oil shock, and as a result now has 59 of those 152 EU reactors. Public attitudes in other European countries to nuclear power have been shaped by issues such as reactor safety and particularly the lack of long-term nuclear waste

disposal. Not surprisingly, people are reluctant to contemplate new reactors producing new waste before ways have been found to deal with old waste from old reactors.

After long consultation and a very Nordic process of consensus-building, Finland took the decision on a long-term burial site for nuclear waste and, then, felt able to decide to build a new reactor nearby. This contrasts with France, which has still not decided on a final waste depository but whose society is evidently ready to follow the state's lead in nuclear matters. The UK is somewhere in between France and Finland. As Malcolm Grimston has put it, Britain is 'more market-oriented but with governments which seem confused as to whether markets and consultation (on the one hand) or central diktat (on the other) are the appropriate mechanism for managing the interface between science and society'.¹

What is clear is that the EU has done little to make individual countries' decisions about nuclear power any easier, let alone fashion a common policy. This is despite having, from the outset in 1957, the Euratom treaty which aims to promote nuclear energy in general and in particular uranium fuel supply, operational safety in reactors, safeguards against weapons proliferation, nuclear research, and has, in addition, a large staff to carry out these tasks.

Proliferation safeguards

Since 1970, when the Non-Proliferation Treaty (NPT) entered into force, the task of policing this United Nations treaty has been left to the UN's anti-proliferation body, the International Atomic Energy Agency (IAEA). But by that time, Euratom had already developed its own elaborate safeguards to prevent the spread of nuclear weapons, not least because in 1957, with Germany only recently allowed to rearm and join NATO, France wanted Euratom designed to keep an eye on any German atomic activity. (French desire to monitor Germany also lay behind the

¹ Malcolm Grimston, 'The importance of politics to nuclear new build', Chatham House report, 2005, p. 42.

Euratom requirement that the Commission must be informed of any nuclear investment, and periodically the Commission publishes the state of EU nuclear investment plans to give them more transparency.)

Since bureaucracies are loath to renounce any rationale that keeps them in being, Euratom inspectors have kept on inspecting EU reactors, just as IAEA inspectors do. Duplication in so sensitive an area may not be an expensive luxury in this era of terrorism. And it is true that the Commission has recently scaled down the Euratom inspectorate, which numbered 180 people in 2006, as the result of more coordination with the IAEA. But even in the one area of inspection where there is no overlap with the IAEA, one has to wonder at Euratom's purpose.

In contrast to the IAEA, which has to respect the special privileges that the UN Security Council's five weapon states have under UN law in the NPT, Euratom has the right, under EU law, to inspect the civil installations of Europe's two weapon states, Britain and France. Euratom prides itself on this. Yet what precisely is there to safeguard here – apart from preventing outside theft of nuclear material which one must assume to be also a British and French concern – when Britain and France have openly (and in terms of UN conventions, legally) turned atomic material into bombs?

Fuel supply

Euratom's supply agency was created to ensure member countries' reactors got fair and regular access to nuclear fuel. The original expectation, at a time when there were relatively few sources of natural uranium and when the US was virtually the only provider of enriched uranium, was that it would need to manage a shortage of supply. In reality, there has been abundance, and as a result, the supply agency's role has moved from one of promoting imports to controlling them.

Nuclear supply contracts within the EU need Euratom approval. Indeed, in its early years Euratom used to be the co-signatory on all nuclear supply deals (except for France's contracts with Niger and Gabon, which Paris regarded as its

private preserve). The big change in the market, for Europe, came in the early 1990s when, after the Cold War, Russia started to offer large quantities of natural and enriched uranium to the European market. Natural uranium imports pose no competitive threat to the EU where natural uranium is not mined. But enriched uranium imports do compete with enrichment plants in the EU. In particular, low cost Russian enriched uranium was judged to threaten relatively high cost EU enriched fuel, especially that made by Eurodif in France and by Urenco in the Netherlands.

As a result, when the EU signed its Partnership and Cooperation Agreement (see Chapter 9) with Russia in 1994 on the Greek island of Corfu, it adopted on the side a unilateral declaration on imports. The Declaration of Corfu, which has never been formally published, is to the effect that the market share of EU uranium enrichers should be maintained at around 80 percent, for reasons of security of supply. (The principle of setting a limit on imports was also confirmed for natural uranium, but for the reason mentioned above, this was less sensitive).

This effective limit on imports from Russia to 20 percent of the EU market has since bedevilled EU-Russia relations. As the Commission noted in 2002, 'every official meeting, including EU-Russia summit meetings, is treated as another opportunity for the Russians to protest about [nuclear fuel] restrictions and to call for a satisfactory resolution on trade in nuclear materials.'² In the last few years the restriction has come to bother Moscow slightly less because it has been making so much money selling oil and gas to Europe. But the issue has not disappeared as an irritant in EU-Russian relations, and will certainly re-emerge in any negotiations for a new EU-Russia agreement.

However, it is not proliferation fears or fuel worries that deter EU countries from developing or maintaining nuclear power, but rather the issues of operational safety, waste disposal and reactor decommissioning that worry their voters.

2 Commission Communication on nuclear safety in the EU, COM (2002) 605 Final, pp. 5–6.

Safety

Euratom sets basic standards for radiation protection for people working in reactors. But bizarrely it has no role in setting safety standards for the design or operation of reactors, when for the population at large the risk of radiation exposure comes from faulty reactor design or operation. EU member states have always insisted on regulating their own nuclear installations, and setting their own reactor safety standards. 'Nuclear safety and radiation protection are now two closely linked concepts serving a common health protection objective', complained the Commission in 2002. 'Consequently it is now no longer possible or desirable to separate these two disciplines.'³ But nothing has changed since 2002.

EU countries have, often to their detriment, had their own special ideas about reactor design. The UK is the classic example, where special UK-only designs for the Magnox and Advanced Gas-cooled Reactors (AGRs) have made impossible the sharing of economies and lessons with other countries and other nuclear programmes. A current instance of national particularism in reactor design is the European Pressurized Water Reactor (EPR) which the French-led consortium is building in Finland, and whose cost over-run and delay is partly due to design changes demanded by the Finnish regulators. This is unfortunate in the sense that TVO, the Finnish power company ordering the reactor, has been collaborating with other European companies to develop an industry-led harmonization of reactor design in the 'European Utility Requirement' (EUR) initiative. And TVO had used EUR as the bid specifications template for its new reactor.

It is not surprising that nuclear regulators differ, for they often have not only different ideas of what is safe, but different ways of arriving at those ideas. 'The Germans traditionally took a very prescriptive approach to reactor design,' notes one EU expert, 'whereas the UK and French regulators have tended to leave it to the companies to prove a design is safe.'⁴ Lack of a common

³ Ibid, p. 7.

⁴ Author interview 2008.

standard or design across Europe obviously poses problem for any reactor manufacturer trying to gain economies of scale in replicating the same model.

In recent years, what evolution there has been towards common safety standards has come from the work – outside of the EU and Euratom – of the Western European Nuclear Regulators Association (WENRA). But in 2007, the Brussels Commission took a more proactive approach by setting up the European High Level Group on Nuclear Safety and Waste Management. Mainly composed of the EU's 27 national nuclear regulators, this body may in time produce a common approach in its two areas of responsibility.

Waste disposal

This is the issue that most exercises people about nuclear power. Indeed, according to a July 2008 Eurobarometer opinion survey, 40 percent of opponents of nuclear energy said they would *change* their mind if some safe and permanent solution could be found for radioactive waste. In the same survey, more than 60 percent of respondents wanted an EU role in monitoring national management plans for radioactive waste, and felt such national plans should be required and harmonized across Europe.⁵

Governments are often asked, 'How can you possibly decide to build new reactors when you have not decided what to do with waste from existing ones?' So far, only one has come up with an answer. Finland only decided to go ahead with building its latest reactor after it had decided on a final geological depository for nuclear waste, the first country to do so.

On so sensitive a matter, the EU or Euratom would be ill-advised to tell countries what to do with their nuclear waste, provided its basic conditions for radiation protection are met. Nor can it dictate the timetable for countries to decide on waste disposal. But what the EU could have done is put more effort into researching ways of permanently and safely storing nuclear

⁵ Eurobarometer surveys, http://ec.europa.eu/public_opinion

waste that governments could draw on, particularly if they are contemplating building new reactors.

One measurement of effort is money. In Euratom's 2002–2006 sixth framework programme, a mere Euros 90m was devoted to radioactive waste management, plus part of the Euros 290m nuclear research budget of the EU's Joint Research Centre. Compare this, however, with the Euros 750m that went over the same period to research into fusion. This distant dream of fusing atoms to reproduce the energy of the sun continues to eat up EU research money. In the seventh framework programme for 2007–13, of the Euros 2.75bn going on nuclear research, fusion will get Euros 1.947bn, compared to Euros 287m on solving the rather more immediate problems and issues of fission and radiation protection.

'I think the money for fusion should be more calibrated, because fusion is always 40 years away in the future and focusing on fission is more realistic', says Santiago San Antonio, director general of the Foratom nuclear industry association.⁶ He points to the creation in 2007 of the Strategic Nuclear Energy Technology Platform to research the fourth generation of fission reactors as the sort of 'recalibration' he wants to see.

It should, however, be said that some EU nuclear experts believe that the EU should not necessarily be spending more money on more basic research into waste disposal, but rather on applying the techniques that are known to the potential burial sites. 'We are not really now doing basic research on waste, and we don't need to', says one expert. 'What we do need is more *in situ* testing, to get digging, looking at the geology of potential sites and doing things like heat tests on the rocks.'⁷ However, such *in situ* work generally requires sites to be chosen beforehand by EU countries. This creates a circular chicken and egg problem, with the EU only able to provide the research that would help states choose storage sites if the states have already chosen the sites.

6 Author interview, 2008.

7 Author interview, 2008

An attempt at change

Euratom – or the European Commission into which Euratom's secretariat was subsumed in 1968 – did have a serious try at reform in 2003. In January of that year, the EU executive proposed draft directives on common rules on reactor safety and for funding the decommissioning of reactors, as well as on an obligation on member states to set a timetable to bury their radioactive waste.

This was not exactly a bolt out of the blue. The directives were partly drafted to reflect in EU legislation two international conventions that had already been adopted by most member states, after a typical EU institutional fight over treaty competences. In 1996 EU states negotiated within the IAEA the Nuclear Safety Convention. This did not create any requirement for a European safety standard, because there was the IAEA one. But when the Commission proposed that the EU, as Euratom, become a party to the convention, a number of member states objected, and the Commission took the issue to the European Court of Justice. While the appeal was being considered, EU states negotiated another convention in the IAEA, the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, which the Commission also wanted Euratom to sign. Eventually, the European Court of Justice ruled in 2002 that the EU had competence in nuclear safety, and so Euratom got to sign the conventions.

But the real catalyst for Commission action at the turn of the century was, in a way, the very event, the 1986 Chernobyl accident, that had cowed the Commission into silence on nuclear matters through most of the 1990s. As the prospect neared of enlargement and of East European states bringing their Chernobyl-style reactors into the EU with them, so concern about nuclear safety grew. In the late 1990s the Commission started to negotiate the closure of the riskier reactors from candidate countries, but found itself bitterly criticised by East European governments for having no proper criteria – because no EU safety standards – by which to judge them.

Eventually, the late Loyola de Palacio, a feisty Spanish conservative who was commissioner for energy as well as transport,

decided to exploit impending enlargement to East Europe to advance a more proactive EU nuclear power. So, armed also with the ECJ ruling that backed Euratom's competence in nuclear safety, she unveiled her draft directives in January 2003.

The proposals got the backing of the European Parliament, but were attacked from many other quarters. A majority of member states supported the Commission. This was not surprising, because nuclear safety issues were already figuring in EU summit communiqués.⁸ But some governments regarded Ms de Palacio's proposals as a Commission power grab (which in part it was), and saw no problem in perpetuating double standards on safety, one for existing club members, another for newcomers. They also disliked, on subsidiarity grounds, Brussels involving itself in the details of decommissioning and waste disposal. There were enough objecting governments to form a blocking minority. Within this blocking minority, the UK was the most active. According to one official, 'the UK's strong objections were related to its worries that its Magnox reactors would not stand up to European scrutiny of safety, and to the fact that no decision had been taken in the UK, at that time, about geological disposal being the best way to go with radioactive waste material.'⁹

The nuclear industry itself was fairly supportive. It believed the directives would have pushed member states towards the harmonization of safety standards and towards decisions on waste management programmes that it, the industry, wanted in order to develop the sector. For their part, environmental groups believed, with some cause, that measures ostensibly designed just to increase nuclear safety had the wider purpose of revitalising an industry they oppose. For this reason they found themselves in the uneasy position of opposing clearer regulation on safety and on the necessity to publish nuclear waste management plans.

In September 2004, the Commission watered its proposals down, but not sufficiently to give them any chance of passage

8 The Laeken summit of 2001, for instance, said 'the European Council undertakes to maintain a high standard of safety in the Union'.

9 Author interview, 2008.

through the Council of Ministers. "Eventually we will need legislation on nuclear safety and waste", Dominique Ristori, the Commission's top nuclear official, said in mid-2008. "2003 was a bit premature [for agreement on the directives], but at the right moment we will come back with legislation which will be based on the fundamental rules already agreed internationally in the two conventions."¹⁰

In fact, the Commission judged 'the right moment' to revive one of its proposals was as early as November 2008, when it proposed a recast directive on nuclear safety.¹¹ However cynics might say the Commission's timing was mainly to satisfy France's desire for a nuclear proposal during its autumn 2008 spell in the rotating EU presidency. For the 2008 proposal was still weaker than the 2004 one, which had itself been diluted with the abandonment of an EU fund for reactor decommissioning. In 2008 the Commission stressed its recast proposal was to strengthen the role and independence of national nuclear regulators, who had played a big part in opposing its earlier draft directives. Virtually the only *communautaire* element in the 2008 proposal was the requirement that national nuclear regulators submit every 10 years themselves and their national systems to 'international' (left unspecified) peer review. Meanwhile, the 2003 directive on nuclear waste disposal, proposed in 2002 and revised in 2004, remains in limbo.

Nonetheless, the Commission has at least tried to dissuade more governments from abandoning nuclear power. In its spring 2006 green paper, the precursor of the present strategy, it reminded member states that while they were free to choose their energy mix, 'decisions by member states relating to nuclear energy can also have very significant consequences on other member states in terms of the EU's dependence on imported fossil fuels and CO₂ emissions.' The green paper made exactly the same point about the need for member states to consider the effect on the wider Union of their decisions on gas. 'Decisions to rely largely or wholly on natural gas for power generation in any given member states have significant effects on the security

10 Author interview, 2008

11 COM (2008) 790/3.

of supply of its neighbours in the event of a gas shortage', it warned.¹²

Italy is a case in point on both counts. Having closed down all its nuclear power plant at home, it imports very large amounts of gas and runs a chronic deficit in electricity trade, including imports of French nuclear-generated power. These are evidently the sort of considerations that the Commission wishes the Italian people had taken into account in 1987, when, in the immediate wake of Chernobyl, they voted by referendum to shut the country's nuclear power plants.

De Palacio's successor as energy commissioner, Andris Piebalgs, has been more circumspect in promoting the EU dimension in nuclear policy. On a purely personal level, this would be understandable. A Latvian who was a Soviet citizen in 1986, Mr Piebalgs was kayaking in Ukraine at the time of the Chernobyl and only found out about it two days after it occurred. Nonetheless, as energy commissioner, he has accepted nuclear power's essential role in climate change policy. In 2007, he has oversaw the creation of the High Level Group of national regulators to discuss safety and waste management, and the opening of the European Nuclear Energy Forum as a talking shop that will regularly alternate between Bratislava and Prague. The willingness of both the Czech and Slovak governments to host this forum is a sign of East European countries' seriousness about nuclear power. They tend to regard it as a surer road to a low-carbon economy than renewable energy.

Certainly the economics of nuclear power are better than for some time. Uranium prices rose 10 times in the 2003–7 period, though they have fallen back since. However, even at its price peak uranium still counted for much less in the cost of electricity it generates (because of the very high capital cost of reactors) than fossil fuels do. Nuclear power cannot for the moment expect the same overt public subsidy that goes to renewables. Nor does Mr San Antonio of Foratom believe it needs any state aid, 'just a stable framework over a long period in which to recover the investment'. Thinking of his own country, Spain,

¹² Green Paper, 'A European Strategy for Sustainable, Competitive and Secure Energy', 2005, p. 9.

he says, 'nuclear energy cannot be a political football at every four-year election.'¹³

But nuclear power operators now reap advantage from the system of carbon permits (traded on the Emission Trading Scheme) that penalizes rival generators using fossil fuels. So, for the first time in many years, the EU dimension is making a real contribution to nuclear power. The technology-neutral characteristic of the ETS, which rewards all low-carbon technologies alike, is one of the beauties of the system.

It is not surprising that nuclear power's main financial assistance these days should have to come in rather disguised form through the ETS. For over the past 50 years, the consensus that once existed in favour of nuclear power has evaporated. How can 'Europe' actively promote nuclear power, when people throughout the EU institutions – the Commission as well as the Parliament and Council of Ministers – are split over it? Because Euratom is a founding treaty of the EU and was signed long before opt-outs were created to cater for awkward members such as the UK, it has been part of the set menu for all, something that all new members have signed. This may have been a mistake. The EU now has some viscerally anti-nuclear members, especially Austria and to some extent Ireland, which are full members of Euratom. They are against nuclear power not only for themselves but also for others. They can be an obstruction to progress, just as Britain would have been had it been forced into the common eurozone currency zone or the Schengen free-travel area.

An example of Austrian obstructionism came in February 2008 when Austria threatened to block energy ministers' agreement on the new Strategic Energy Technology plan unless it carried a guarantee that no money would go to nuclear research. A temporary compromise to please the Austrians was found whereby the SET plan was approved, but the financial consequences of that approval were left to be decided later.

In these circumstances, one can argue that Austria should abstain, or opt out, rather than obstruct research that might one day make nuclear power palatable even to Vienna itself. Indeed,

¹³ Author interview, 2008

why not have in the nuclear field the sort of variable geometry successfully tried in other areas, such as the euro currency zone, Schengen or EU defence? This would allow the Austrias and Irelands to opt out of Euratom, and turn Euratom into a sort of 'coalition of the nuclear willing'.

The snag is that no one wants to opt out of Euratom. As long as it exists, Austria and Ireland want to participate, if only to keep an eye on their neighbours' nuclear power plans. There was a moment in 2004 when change seemed briefly possible. During negotiations on a new constitution, five countries – Germany, Ireland, Hungary, Austria and Sweden – declared their interest in an intergovernmental conference to review the terms of Euratom. But they found no wider support, and the issue was dropped and is likely to stay dropped. Subsequent events with the Treaty of Lisbon have shown that EU treaty negotiation, and especially ratification, is contentious enough without adding in the nuclear power issue.

In reality, countries that are undecided about nuclear power may be more of an obstacle to Europe's low-carbon energy development than the outright opponents to it. In the undecided camp must be counted those countries – Belgium, Spain, Germany and Sweden – which have agreed to phase out nuclear power, but necessarily over long periods that provide opportunities for politicians to change their minds. Such countries fall between two stools. They make no plans to build new reactors, but as long as the possibility of a U-turn exists, they also shy away from committing themselves absolutely to replacing all their nuclear power with alternative energy. Germany and Spain have increased their renewable energy enormously, but not by enough to fill the energy vacuum that phase-out of their reactors will leave. How to plug this nuclear vacuum in the future is one of the challenges for Europe's energy research and development programmes to which we now turn.

CHAPTER 14

ENERGY R(ELUCTANCE) AND D(ELAY)

This market gap between supply and demand is often referred to as the 'valley of death' for low carbon energy technologies.

The European Commission on launching its energy technology plan in November 2007

Develop a new technology in every other sector of the economy, and you will usually have a market for it. As long as it does something new – not even necessarily useful (think of kids' electronic games) – or does something old but in a cheaper or better way, then you will have ready customers. Not so in energy. There seems to be an inbuilt lack of market interest in new energy technology that makes energy innovation especially difficult.

The problem is not a question of long lead times (except in nuclear fusion which always seems to be 40 years from commercialization). It is only partly the network challenge of connecting new energy sources to grids or transforming grids to suit decentralized power sources so that energy reaches everyone. Mainly, the problem is that low carbon electricity technologies are almost always more expensive than those they replace, but provide nothing more than the same old electrons. Equally, carbon capture and storage (CCS), which is another way of keeping carbon out of the atmosphere, is in a sense an assault on productivity, a step backwards. CCS is perfectly justifiable, because it is for the greater good of the planet, but is nonetheless a technology that has the effect of reducing the electricity output of the average power plant to what it was some years ago. This is because the process of capturing the CO₂ and pumping into underground storage itself requires power.

Energy efficiency measures, examined in Chapter 15, have a payback in lower energy bills. But in the case of households, this