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new nuclear power:
implications for a sustainable energy system

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executive summary

The government has four clear goals in energy policy: reducing carbon dioxide (CO_2) emissions; maintaining energy security; promoting competitive markets and ensuring affordable heating (as set out in the 2003 Energy White Paper). This report examines the impact that new nuclear power could have on the UK's energy system and its energy goals.

Nuclear power provides around 20 per cent of the UK's electricity (or about 8 per cent of its total energy). Assuming that a programme of new reactors will only replace existing plants, new nuclear build has, at best, only a limited potential to reduce the country's CO_2 emissions.

Given the financial and institutional commitments implied by a new nuclear programme, it is therefore essential to examine what impact it would have on the rest of the UK's liberalised electricity market which provides 80 per cent of the UK's electricity. Furthermore what impact would it have on the other 92 per cent of the UK's broader energy market and on a move towards a more decentralised, sustainable energy system?

1. The requirements for building nuclear power plants.

- No nuclear power stations have been completed in a liberalised energy market. The unique risks associated with nuclear power need to be sufficiently reduced to encourage investment in such a programme. A risk reduction programme would almost certainly have to cover the lifetime of a station, from construction to operation and final decommissioning and nuclear waste management. The costs of reducing risks would ultimately fall on taxpayers or consumers.

- Investors would have to be sure of an acceptable price for the electricity output from new nuclear power stations to ensure an adequate rate of return, and would also have to be certain that nuclear stations would operate as base load generation.

- The cost of building new nuclear power stations is uncertain, as is the cost of generating power from new reactor designs. Support would therefore have to be given before the true costs of nuclear power were known.

2. What effect would these requirements have?

- Building new nuclear power stations would lock the UK into a centralised energy system for the 60 year lifetime of the stations, which would mean that the benefits of a decentralised system would not appear.

- It is desirable to keep energy options open to adapt to changing circumstances in the future. Innovation in a wide range of technologies therefore needs to be encouraged to maintain flexibility. The inflexibility of a large investment and construction programme for nuclear power would mean the project would acquire a momentum of its own and would be difficult to abandon if the economic or demand rationale evaporated.

- Nuclear power stations are inflexible generators, they are unable to follow the peaks and troughs of demand and therefore have to operate at a more or less constant level of output. Guaranteeing nuclear a proportion of base load electricity, to ensure investment, would mean that not only would the electricity market be reduced substantially in size, but other technologies would have less certain markets for their output, making them a less attractive investment option.

- The cost of delaying emissions reductions until new nuclear comes on line would be more than the cost of a linear reduction strategy.

- The scale of the financial, political and institutional commitments required to build new nuclear power plants will undermine support for new technologies (such as renewable generation) and demand reduction measures, which are vital to achieving a low carbon economy.

- The undermining of other technologies means that nuclear power is not complementary to other low carbon technologies. This refutes the argument that all low carbon technologies should, and are able to, be harnessed together so that they can harmoniously work together to reducing carbon dioxide emissions. On the contrary, the government has to make a choice between a nuclear future and one dominated by renewable generation and the more efficient use of energy.

The implication is therefore that new nuclear power will not contribute to the UK's energy policy goals and, we believe, will actively limit the UK's ability to meet its climate change targets.

3. Nuclear power's ability to help with energy goals

At best, the current fleet of nuclear power plants will be replaced. Yet, because the programme undermines rather than complements the development of other low carbon technologies, there will not be sufficient development of renewables, demand reduction technologies and energy system change to transform the other 80 per cent of the electricity generation market (or 92 per cent of broader energy) into a low carbon energy system.

At worst, the majority of nuclear power plants will not be replaced (because of cost or public opposition), while development of a low carbon energy system will stall. Support for nuclear power could therefore lead to a scenario where:

- Climate change targets are unlikely to be met;
- Security of supply for both heating and electricity production is not enhanced because, at best, new stations will not come on line until 2018;
- Efforts to reduce domestic demand, arguably the most complex and politically difficult sector, will not be put in place. Demand will grow, increasing future capacity requirements thereby increasing gas dependence and energy security concerns;
- Increased consumer prices, combined with slackening of efforts to reduce demand, could threaten the government's goal of reducing the numbers of fuel poor;
- The support measures needed to drive a nuclear programme counteract many of the benefits in openness and transparency achieved from privatisation and liberalisation, and
- The value-added policy benefits of a low carbon energy system will not take place. These include the cross-overs between consumer attitudes towards renewables and demand reduction; between energy, waste resources and agriculture; and the broader social benefits of innovation.

This scenario illuminates the level of risk to the government of following such a path. It is all too easy to imagine a scenario where, despite the government's best efforts, only a few nuclear power stations are built. In trying to enable this, renewables and demand reduction are undermined and international commitments to reduce carbon emissions are breached. Even worse, government commitment to nuclear power so undermines investment that the required investment in natural gas power stations falters, thereby causing real energy security concerns. Moreover, the government finds itself locked into support for the two or three nuclear power plants it did manage to get going.

Supporting nuclear power would allow the government to appear to be doing something to combat climate change while avoiding the need to make the much harder but more important policy choices which are central to any serious attempt to reduce CO_2 emissions. This would require an understanding of personal consumption and efforts to curb demand while developing a new energy system based on new technologies and a service, rather than sales, culture.

Nuclear power undermines rather than complements other low carbon technologies. Support for a nuclear programme will not address the real problem of the UK's climate change emissions or the government's other energy policy goals, but will ultimately strengthen the characteristics and problems of the 'old' energy system, thereby making that energy system even harder to dislodge.

1. introduction

Nuclear power has gradually reappeared on the UK's energy policy map. The resurrection of interest in the technology comes fifteen years after the privatisation of the electricity supply industry exposed nuclear's high costs and forced the (then) government into an embarrassing retreat from its privatisation plans and a programme of new reactor construction.

This new interest in nuclear power comes despite the 2003 publication of an Energy White Paper (EWP) which, after two years of research, ruled out nuclear power on the grounds that its economics made it 'an unattractive option', and deemed it was an inappropriate generating choice at that time[1].

However, the White Paper also stated that nuclear power should be kept open as a possible future generating option. Since the EWP's publication, nuclear supporters have written a stream of reports and articles questioning its recommendations and arguing that the issue should be re-examined[2]. The Chief Scientist and the CBI have joined in recently, arguing that the government should revisit its energy policy[3].

The Prime Minister has accepted the arguments to revisit the EWP, stating recently that 'the facts have changed over the past couple of years'[4] in relation to energy policy. On 23 January 2006, the DTI released the consultation document, *Our Energy Challenge*, which aimed to reassess how the UK meets its targets for reducing carbon dioxide emissions. This includes 'looking again at nuclear power'[5].

The 2003 EWP set out four goals for energy policy:

- To put the UK on a path to cut carbon dioxide emissions by some 60 per cent by about 2050, with real progress by 2020;
- To maintain the reliability of energy supplies;
- To promote competitive markets in the UK and beyond, and
- To ensure that every home is adequately and affordably heated.

The current debate on energy policy focuses on how to maintain energy security whilst meeting environmental targets. Is nuclear power the answer to this question? What impact will it have on the fuel poverty and competitiveness goals in the UK's energy policy?

1.1 UK climate change policy

The UK has a number of targets in place to reduce its greenhouse gas emissions. Its legal Kyoto target is to cut greenhouse gas levels by 12.5 per cent from 1990 levels by 2008 - 12. The Energy White Paper also confirmed a domestic target, to cut CO_2 emissions by 20 per cent from 1990 levels by 2010. In addition, there are a number of other targets relating to the promotion of renewable energy, energy efficiency and Combined Heat and Power (CHP) technologies. All these targets could be met by a different cocktail of energy policies[6].

The UK is currently off track to meet its domestic 20 per cent target, and emissions from the electricity sector have been rising steadily since the late 1990s. In 2004, CO_2 emissions were only 4 per cent below 1990 levels overall[7]. On the basis of current firm policies, the government estimates that CO_2 emissions may only be about 10.6% below 1990 levels by 2010[8].

To address this shortfall, and get the UK back on track, the government launched a review of its overarching climate change policy. This has yet to be published, and its outcome, along with the results of the Stern review[9] and energy review will be revealed this year alongside more specific studies on micro-generation for example.

1.2 the nuclear question

Those in favour of new nuclear build have argued that:

- Climate change is such a serious issue that all options to combat it need to be looked at and used together;
- Addressing UK emissions of CO_2, in particular by concentrating on deploying new renewable technologies, would harm UK competitiveness;
- Current renewables delivery and demand reduction policies will not ensure energy security;
- The UK should not become dependent on natural gas, and
- Nuclear power complements other low carbon technologies or measures.

The difficulties in combating carbon dioxide emissions mean that announcing a return to nuclear power would seem to offer a number of tempting benefits:

- It will, at best, be over a decade before a nuclear power plant is finished so it delays the problem of reducing carbon dioxide emissions while at the same time allows the government to be seen to be doing something;
- The projected addition of large amounts of nuclear capacity will remove the pressing need to implement demand reduction measures, so the government will not have to put in place politically unpopular policies;
- It allows the government to state that it has put measures in place that will ensure sufficient future capacity, and therefore allay energy security fears. This enables the government to argue that there will be more time for the other alternatives, renewables and demand reduction, to develop.

The essential problem for those who argue for 'evidence-based' decision making and policy is that it is not possible to know what the future holds. Both sides of the energy policy argument can put forward their views. This report debates the statements above and, where possible, we provide evidence to support our arguments.

However, we believe that choosing to pursue new nuclear build will not contribute to further reductions in carbon dioxide emissions, particularly in the short to medium term. Nor will it help with the short term security of gas supply concerns which are currently being raised. Instead, the scale of the financial and institutional arrangements needed for new nuclear stations will undermine the implementation of low carbon technologies and measures such as demand management, and therefore will ultimately undermine the shift to a true low carbon economy.

Nevertheless, we cannot provide *proof* that our concerns will become future reality. But the potential impact of any decision to build new nuclear stations means that these concerns must play a central role in the policy debate. This is at the heart of all political debate about public policy. The lack of certainty about the future often allows governments to do what they want, given a number of options.

The report considers the following issues:

- The arguments put forward by those in favour of new nuclear construction and asks a number of questions about what could be expected from a nuclear programme;

- What would be needed to get a nuclear power programme going and what the impacts of that would be on renewable energy, demand reduction and other low carbon technologies (including control technologies);

- The impacts on the political and institutional resources available for a transition to a non-nuclear low carbon energy system and on broader personal consumption and sustainable development issues.

It concludes that nuclear power does not complement the necessary shift to a low carbon economy as it would fatally undermine the development of other low carbon options.

2. developing a sustainable energy system

2.1 introduction

The danger of any debate about new generation is that it can be based on simplistic notions of the electricity system and assume that a new generating station can be developed and plugged into the grid without broader consequences for the rest of the system. In fact, electricity and energy systems can be better understood as complex sets of interacting components encompassing institutional, political, legal and social factors as well as technical elements. These components include the market in which generating technologies operate; the design and style of regulation; the rules and incentives governing the operation of electricity networks, and the ways in which people view and use electricity supply. Each of these components influences, and is influenced by, other components.

Policy on electricity generation, and energy more generally, has to take into account the interaction between these components. This is necessary if the long-term development of the UK's energy systems is to play a role in achieving the government's CO_2 reduction targets.

2.2 the UK's electricity system

The UK's electricity system is highly centralised – in other words, it is dominated by large scale (up to 1GW) generating stations. Power is transported from these stations towards centres of demand, often miles away, along high voltage transmission lines. A proportion of this power is lost during transport. Lower voltage distribution lines take the power from the transmission network and deliver it to the point of demand. Because generation is injected into the transmission network, it has to be operated in a reasonably active manner, meaning that electricity flows are two way. In contrast, distribution networks are largely designed to be passive –the design and operation of the network and its security is based on a downward flow with limited two directional flows.

Early electricity networks were small scale, operating over well-defined geographical areas such as individual towns or areas of cities. The development of a more centralised national system was initially driven by the potential for economies of scale in generation and complemented by the development of transformers, which in turn allowed the construction of high voltage transmission lines[10]. Building large, remote generating plants gradually became the logical choice for meeting increasing demand for power, and distribution lines, initially active participants of the emerging system became increasingly passive. Subsequent choices made for generation and infrastructure gradually reinforced the centralised characteristics of the system and excluded smaller scale or less centralised technologies on the basis that they did not conform to the dominant model.

This technical configuration has been supported by an environment constructed to allow the centralised system to work effectively. This includes manufacturing capacity, educational programmes, and institutional factors such as the rules and incentives that govern the operation of the transmission and distribution networks and latterly, the design of electricity markets. At a lower level, these rules and incentives are the basis of the internal financial regimes developed by energy companies for their costs and revenues, which in turn influences investment decisions about future generation technologies. This broader arena in which technologies are developed, chosen and used has been called the 'selection environment'[11].

The historian of technology, Thomas Hughes, has likened the increasing dominance of certain technological options and the consequent exclusion of others to momentum which pushes the system along a certain path of development[12]. Related concepts can also be found in economic literature, where certain technologies can be described as 'locked in' once they have achieved a level of dominance in their adoption.

The most quoted example of this is the QWERTY keyboard, which is the dominant design despite the availability of arguably superior keyboard configurations[13]. Once the QWERTY configuration achieved a certain degree of market penetration, it effectively became insulated from other layouts because users would find it difficult to adapt to another configuration. Equally importantly, other factors such as the processes set up to manufacture keyboards of that design, to manufacture typewriters which would incorporate it and to train people in their use, also played a role in locking in the keyboard configuration. Changing the configuration of the keyboard would therefore have both a social and an economic cost, and despite the fact that it is apparently inferior, it continues in use because there is no overriding pressure for its change.

Nuclear power stations are the epitome of centralised generation: they are large scale (up to 1 GW), remote, and heavily reliant on the transmission network. They therefore conform to the current technical model for operating in the UK's electricity system. The industry's demise over the last fifteen years came about because of wider issues; in particular, privatisation and the introduction of competition exposed the industry as an unattractive investment option. If investment risk is reduced, and if new stations were built, then they would be able to connect to the system without any major adaptation of the system's current configuration.

In contrast, renewable generation and combined heat and power stations tend to be connected to distribution lines, which have not been designed to operate actively, given the dominance of the transmission-based model. Projects are often small scale (tens of MW) and sited close to a point of demand. In this sense, they do not conform to the current dominant characteristics of the system.

2.3 a decentralised energy system

The general characteristics of a centralised system have begun to be questioned, in part because of the environmental impacts of large scale, mainly fossil fuelled, generation. The economic risks of developing capital intensive, big power stations in a liberalised electricity market must be considered alongside the availability of new technologies across the energy spectrum of supply, demand and control[14].

There is increasing recognition that the electricity system, and energy systems more generally, needs to be more environmentally sustainable and based on technologies that are compatible with reducing emissions of greenhouse gases. The operation of nuclear stations can meet this criterion (although, because of the energy-intensive nature of their construction and fuel supply, the level of their life-cycle CO_2 emissions is disputed[15]). In addition, their operation inevitably entails the other long-term and intractable environmental problem: the creation of nuclear waste. Although nuclear power might be able to operate without direct CO_2 emissions, the creation of nuclear waste means that it is not an environmentally sustainable generating option.

The recognition that centralised electricity systems entail significant environmental problems, as well as being capital intensive and therefore risky, has led to a growing interest in the possibility of decentralised systems. A decentralised system would incorporate a wider spectrum of different sized generating plants, including mostly renewable technologies, increased use of demand management and the active involvement of distribution networks to receive power from, as well as deliver power to, consumers[16]. As well as lower CO_2 emissions than the current system, the use of mixed scale technologies offers a number of other benefits such as:

- Greater efficiency in generation and supply of electricity as less power will have to be transported over long distances, so reducing losses;
- Greater resource productivity;
- A move from a unit sale to a service culture, with the prospect of resulting increases in energy efficiency, and
- Greater customer involvement in energy decisions.

Box 1

A decentralised energy system

A decentralised energy system in this report is taken to mean:

- A system where energy and electricity demand and supply are linked;
- Where power plants are all sizes, from gigawatts down to a few watts;
- Where renewable and highly efficient fossil fuel generation dominates in conjunction with other technologies, such as energy storage;
- Where generation technologies are connected to the transmission grid and distribution networks, from offshore down to domestic dwellings;
- Where distribution networks are active participants in the electricity system, rather than passive recipients of power flowing from the transmission network;
- Where 'smart' information technology is used to design and operate an efficient system which can incorporate demand side management with active, flexible controls of the supply system to increase energy options;
- A system which has active customers - meaning customers who make choices about their energy use, including at the domestic level;

- Where the sales of services has replaced sale units of energy, thereby joining supply and demand;
- A system with the ability to develop and incorporate new technologies of different sizes and in different places (e.g. domestic dwellings and offshore).

A decentralised system is more compatible with the aim of achieving greater sustainability than a centralised one. A decentralised system would be flexible, active, efficient and low carbon and would involve customers. Just as on-line banking now enables customers to make transfers from one account to another without involving bank staff, so energy customers should have the option to become more energy literate, or more in control of their energy use, if they so wish[17].

Electricity systems will need to move from being passively to actively operated if more decentralised generation is to be connected to the networks[18]. Currently, decentralised generation is connected to the distribution network without integration into network operation. This means that the security of the electricity system is maintained without needing or using the distributed generation. There is a maximum limit to the capacity that can be connected in this way, which could be increased if the system was actively operated and managed. Therefore, an actively managed distribution network will ultimately be a prerequisite for increasing levels of distributed generation. Active management could also enable demand management, with appropriate regulatory structures, and would be more efficient in terms of resource use because control technologies should reduce peak, and therefore capacity, requirements.

While the incumbent electricity companies, including suppliers, could continue to be the major players within this energy system it would be a very different culture for them. Tthis system would enable new entrants at every level, thereby introducing risk to the incumbents. While customers would not have to be involved in their energy decisions, a service culture and a move towards micro-generation would enable them to do so.

Box 2 Centralised and decentralised energy systems

Characteristics of a centralised generating system	Characteristics of a decentralised generating system
Transmission based	Transmission network balances power flows around the system
Passive distribution networks delivering power from transmission to final consumer	Active distribution networks with two way flows of power
Few generating technologies	Wide range of generating technologies (and possibly others such as storage)

Large scale generating stations	Mixed scale plant – large and small
Remote plant	Plant often sited close to demand – even at the household level
Inflexible generation	Flexible generation
Long lead time and high capital cost for new plants	Modular technologies with shorter lead times and lower capital costs
Assumes increasing demand	Possible to reduce demand
Sales culture	Service culture
Long term, global environmental impacts	Shorter term, localised environmental impacts

Although the technologies that could make up a decentralised system are available and work, they are yet to achieve any significant level of deployment in the UK, despite government efforts to promote them. Other countries, such as Spain and Germany, have had more success with delivery of these new technologies because they have determinedly made the environment favourable enough, or reduced risk enough, for them to be adopted[19].

The framework outlined above offers some clues as to why this might be: the UK's electricity system has developed over decades to reinforce the centralised model, and technological choices have in the past been driven by the momentum of increased centralisation. New technologies, which do not demonstrate these dominant characteristics, can be seen as 'locked out'[20]. Their adoption is prevented by unfavourable conditions in the 'selection environment' in which the technologies are deployed[21]. Until the selection environment adapts sufficiently to match, or becomes favourable to the new characteristics, new technologies will not be widely adopted.

The question for policy makers is therefore how to achieve a shift from the current environmentally damaging, centralised model to a more sustainable, low carbon, decentralised model based on renewables and demand management. We believe that such a shift is vital not only because of the greater efficiency of generation but also because, without it, demand reduction will be much harder to achieve. Customer involvement is a key aspect of behavioural change, which is vital for a move a sustainable energy economy.

2.4 energy system transformation

Analyses of how a portion of an energy system can develop have occurred since the early 1990s, when most countries began to support renewable energy technologies[22]. More recently, attention has focused on how to achieve a transition to more sustainable technical systems. While conventional economic analysis of technical change tends to focus on pressures that operate visibly at the level of the firm - for example pricing, competition, taxes, regulations, skills and so on – these new studies take a broader approach, applying ideas from policy and innovation studies, sociology and the history of technology as well as economics. Analyses of systems are being developed to account for non-economic pressures acting on system developments, in particular "…institutional structures and conventions, including changes in broad political economic landscapes or wider socio-cultural attitudes and trends." [23]

Policy-making has a key role to play in the future development of the electricity system, although all system actors (companies, regulators and individual consumers) will play a part in its future shape. In this context, government can shape conditions by devising policies which, directly or indirectly, encourage the development of a selection environment which is less hostile to emerging new technologies. It is important to stress that this is not the same as 'picking winners', which involves championing specific technologies. Instead, it ensures that new technologies are not 'locked out' of the existing system. This approach does not in itself guarantee that a technology will succeed, to the extent that it achieves parity with already established technologies, merely that it is not excluded by the conditions in the selection environment devised to maintain the current system configuration.

Whichever approach to system transitions is adopted, research has shown that policies are most effective when they are transparent, predictable and persistent, in order to reduce the degree of uncertainty for those adopting new technologies. Power and agency (ie the ability to act) are fundamental to achieving a transition: if there is little clarity about, or commitment to achieving a shift, then the momentum of the current configuration will not be overcome.

The apparent failure in moving towards the vision in the 2003 Energy White Paper can be taken as a case-study for this. Despite an aspiration for a 60 per cent cut in carbon dioxide from1990 levels by 2050, it did not include a 20 per cent medium-term target for renewables, and so lacked a firm commitment to achieving its aims. Although the White Paper stated that nuclear power should be placed on hold for five years, while renewables and energy efficiency were developed, it also said the nuclear option should be kept open. Combined with the absence of a 20 per cent renewable target, the position on nuclear power gave out mixed messages. It is therefore not surprising that the lack of clarity in the 2003 document has led to the reopening of the debate, rather than concerted action to achieve a renewables target by 2020[24].

2.5 issues of scale

On the basis of current performance, the domestic and transport sectors are proving the most difficult to address from both a political and policy perspective (since 1990, CO_2 emissions from industry have reduced by 12 per cent while residential emissions have increased by 12 per cent and those from road transport by 9 per cent).[25] Furthermore it is at the domestic level that many of the policies needed to move towards sustainable development interlock; these include a sustainable waste strategy, sustainable agriculture and food policy and sustainable energy policy, including transport.

Government struggles with demand reduction because it requires altering the habits of millions of voters. If voluntary and tax measures are not sufficient to lead to emissions reductions, unpalatable regulatory measures might be needed. It would be far easier, so the argument goes, for government to steer clear of this difficult area and build a few big, low-carbon (nuclear), generation plants, to avoid the need to change individual behaviour.

The issue of scale, and the numbers of actors involved in different energy systems, is very important to this policy decision. On one level, it is clearly much easier if the answer to sorting out the electricity portion of the UK's climate change strategy were to build ten or so nuclear power plants. It does not need any fundamental change to the energy infrastructure and, whilst a portion of the electricity market would probably have to be set aside for nuclear, it does not really require any new ways of doing things. The system would still be based on a few energy companies selling units of electricity. This course of action is essentially business-as-usual. It would almost certainly require subsidy, including the government accepting nuclear waste liabilities, but it is a seemingly simple way to solve a difficult problem, and one that many within the energy industry are familiar with.

In contrast, the alternative strategy involves developing numerous new technologies with different characteristics to those of the conventional energy industry. This necessitates new skills; the development of new rules for connection to the grid; upgrades to the transmission and distribution networks; new designs for those networks; new control technologies to enable efficient and secure running of the networks and markets and a move from a sales, to a service, culture.

In order that supply and demand work more closely together, the development of these new supply technologies would link with moves to reduce demand and would increasingly bring in the domestic and transport sector, involving the many millions of households mentioned above.

2.6 could nuclear power be part of a decentralised low carbon energy system?

A decentralised energy system is not a 'small is beautiful' approach but an expansion from the conventional, centralised system to enable new technologies and behavioural attitudes to be valued, accessed or stimulated. Support for a programme of nuclear power plants is more likely to strengthen the momentum of the conventional energy system than enable a decentralised energy system to develop. This is because it would:

- Reduce the pressure for appropriate network infrastructure development;
- Reduce the pressure for policy measures to ensure the removal of barriers within economic regulation for small scale technologies;

Reduce the pressure for policy measures to ensure greater links within an energy system between supply and demand reduction, for example a move to a service culture or a push for metering reform, and

- Reduce the pressure for behavioural change.

There are many new technologies available which could make the energy system more efficient and more accessible to customers but are not taken up because the incentives and rules of the conventional energy system do not encourage them.

2.7 expansion of renewable energy

The UK has a very poor record in terms of delivering renewable energy capacity compared to many other European countries, and if renewables deployment continues at the same low level it allows critical voices, such as the CBI, to say that renewables are unable to deliver sufficient capacity to meet future requirements.

The review of the Renewables Obligation (RO) concluded that the RO should not be fundamentally changed to ensure that investment confidence in this area is not undermined[26].

The European Commission's publication, reviewing Member States' successes in meeting the targets set out in the 2003 Renewables Directive, showed that the delivery of UK policies is more expensive and less successful compared to some of their European counterparts[27]. Other publications have shown this in more detail[28]. Both Spain and Germany added more capacity in wind energy last year than the UK has managed since the inception of its renewable energy policy in 1990. Arguing that renewable energy policy needs stability in order for it to work is also not a reason to continue with the same policies if they are, as is the case in the UK, failing to deliver capacity at a reasonable cost. A degree of flexibility needs to be adopted in the face of this policy failure.

UK renewable energy policy encompasses high investment risk in comparison with most other European countries[29]. The adoption of new technologies is an inherently uncertain undertaking. But by understanding the difficulties and successes of technology development from other countries, and maintaining flexibility, it is more likely that policies can be put in place which remove barriers and establish processes to enable investment and delivery of capacity[30].

2.8 conclusion

In order for a transition to a more decentralised energy system to succeed, government will have to address whole energy system issues which exert pressure, both positive and negative, on the dynamics of system change. The UK government cannot have it all ways; it has to make a choice. If it is serious about wishing to combat climate change and to enable a transition to a low carbon energy system, then it has to choose between the centralised or decentralised energy system; it has to undertake policies which work together and in the same direction; and it has to ensure that the framework environment, including the broader political and institutional support, socio-cultural attitudes and trends are all in line.

3. what could nuclear power contribute and by when?

3.1 climate change targets and timing

In 2004, nuclear power generated around 20 per cent of the electricity that was consumed in the UK. This equated to around 8 per cent of the UK's total energy use.[31] If the aim of a new nuclear construction programme is to replace, rather than expand, nuclear generation then nuclear power can only make a very limited contribution to reducing the UK's overall emissions from energy use. If the plan is to increase nuclear's contribution to electricity supply, it would require a significant expansion, well beyond the eight to ten power plants suggested in the 2001 Energy Review by British Energy or BNFL, to make an impact on the UK's overall CO_2 emissions[32]. Depending on construction start times, even just replacing existing capacity will take an intensive construction period beginning in about 2010-12, following planning applications, and lasting well into the 2020s[33].

That the UK is off track to meet its emission targets has economic as well as technical implications. It is both cheaper and less environmentally damaging to achieve reductions gradually over time than to wait until the target deadline looms and then to make sudden, large cuts in emissions. An update of the DTI's modelling work for the Energy White Paper makes the cost implications of delayed action clear:

> "If action to reduce emissions is delayed, but the same cumulative reduction is achieved as under a linear reduction from 2000 to 2050, the costs increase progressively: the cost of a linear reduction scenario is £58bn. Achieving the same cumulative reduction to 2050 but starting in 2010 costs £72bn and starting in 2020 costs £123bn. If action was delayed until 2030, then such enormous reductions were required in 2050 that they were impossible with the technology options available." [34]

Neglecting the development of renewables and energy efficiency in the short term, on the assumption that emission cuts could be made in the future from replacement nuclear stations, is potentially a very costly strategy, especially as any new station is unlikely to begin operating until 2018 or later. Evidence of the risks of this approach may already be emerging in Finland as a result of the expectation of emissions reductions from the Olkiluoto reactor, which appears to be undermining confidence in the renewables market[35].

As nuclear reactors close, they will need to be replaced with other low carbon forms of generation, or a reduction in demand, if emissions are not to rise, temporarily at least. This means that the development of renewable technologies, coupled with successful demand reduction measures, will be critical to ensuring the UK meets its targets up to 2020. Thus development of renewables and demand reduction has to take place at the same rate as it would without a nuclear power programme.

3.2 nuclear power and security of supply

Proponents of new nuclear power have used the concept of a future 'generation gap' (between available power generating capacity and level of electricity demand) to justify the building of a new UK programme.

The level of electricity generated from nuclear power is set to fall as existing reactors come to the end of their generating lifetime. This process is currently due to be completed when Sizewell B is decommissioned in 2035 (see Table 1)[36]. The majority of existing nuclear power stations are currently due to close within the next ten years or so.

By 2020, the proportion of electricity generated by existing nuclear power stations is projected to only be seven per cent[37]. The amount of nuclear generation in the future also depends on what electricity output level they operate at; the performance of reactors has tended to decline over recent years.

Table 1: UK nuclear stations[38]

Station	Capacity (MW)	Output (TWh)					Published lifetime
		2001	2002	2003	2004	2005	
British Energy							
Dungeness B	1,110	3.66	5.25	5.18	6.66	6.47	2018
Hartlepool	1,210	9.09	8.83	9.34	8.28	5.04	2014
Heysham 1	1,150	8.92	8.11	7.85	6.28	5.11	2014
Heysham 2	1,205	10.05	9.03	9.3	9.81	8.21	2023
Hinkley Point B	1,220	8.23	8.98	8.26	8.11	9.27	2011
Hunterston B	1,190	6.43	9.85	8.93	8.77	8.26	2011
Sizewell B	1,188	8.43	9.22	9.2	8.9	9.12	2035
Torness	1,250	7.71	8.3	5.7	8.15	8.3	2023
Total	9,568	62.53	67.57	63.76	64.96	59.78	
Annual Load Factor2		75%	81%	76%	77%	71%	
BNFL Magnox							
Sizewell A	420						2006
Dungeness A	450						2006
Oldbury	434						2008
Wylfa	980						2010

The projected decline in nuclear output is accompanied by a projected decline in coal power stations, and is coupled with predictions of increasing demand[39].

However, the extent of future generating capacity over the next few years is subject to enormous uncertainty and will be decided by:

- The extent to which government policies and technical developments drive the adoption of renewable technologies;
- The extent to which energy efficiency is improved on both the supply and demand sides;

- The rate at which new, conventional generating stations are built and the factors which will influence this, notably the price of gas and other investment decisions;

- The development of greater interconnections with European electricity and energy systems to allow greater trade between the UK and other European countries[40];

- Government policy on emissions trading and the Large Combustion Plant Directive, and the resulting impact of any decisions on electricity prices and the economic performance of generating plants;

- Whether government and industry decide to pursue carbon abatement technology options to reduce CO_2 emissions from existing and new plant;

- Whether coal and gas power plants have their lifetimes extended;

- Whether British Energy decides to extend the lifetimes of its existing nuclear plants. Life extensions for nuclear plant are a matter of economics: if it makes economic sense to retro-fit plants or repair ageing components, then the operator will continue to generate. British Energy has recently decided to extend the accounting life of Dungeness B by 10 years to 2018, and is working on extending the lifetimes of its other AGR stations[41].

- The time taken for any new nuclear build to come on line. This is not likely to be until around 2018 at the earliest, meaning that new build will make little or no contribution in the medium term either to overall generation capacity.

These factors mean that future development of the electricity system is extremely unclear beyond a timeframe of a couple of years. It also means that there may be sufficient generating capacity in the future because of any (combination) of the above factors.

What is clear is that new nuclear build cannot do anything about short-term gas supply difficulties. Even if it could, the majority of gas is used for heating, something nuclear power cannot contribute to in the short term. The real question is whether natural gas supply is secure enough between now and 2016-2020, when renewable energy is predicted to become competitive[42], and when the first new nuclear power plants may come on line.

If the answer is yes, natural gas is secure[43], then renewables, CHP and demand reduction should be supported as much as possible so that natural gas can move from its position as a transition fuel to transform into the balancer on the system, to complement intermittent renewable generation[44] (as implicitly accepted by the 2003 EWP).

If the answer is no, the UK should be taking urgent action to ensure that we have enough energy to keep the lights on over the next ten years. Nuclear power can do little to help during this period. Action should include extensive demand reduction policies, strong renewable energy policies, developing more efficient fossil fuel technology, such as CHP, and providing incentives to maintain or reopen moth-balled plant. Any action that undermined these developments would exacerbate energy security concerns.

Nuclear power itself can be viewed as an insecure technology. Not only is it a potential terrorist threat, and a source of plutonium, but it could threaten the security of the electricity system itself. Because nuclear power plants are large they can have severe knock-on effects in the event of sudden and unforeseen shutdowns. This was the case in the Swedish/Danish blackout in 2003 which was initially caused by the failure of a nuclear power plant[45]. Once reactors have 'tripped' they cannot be brought back on line quickly, restricting the ability of the system to recover. Furthermore, because they are such inflexible generators they cannot easily generate more electricity to help overcome any system traumas.

3.3 limited contribution to government's other energy goals

Electricity consumers currently pay for action to improve energy efficiency through the Energy Efficiency Commitment, which requires electricity and gas suppliers to promote improvements in energy efficiency in households (fifty per cent of this target must be met by helping low-income consumers). Consumers also pay for the development of renewable energy through the Renewables Obligation, which requires all electricity suppliers to buy a percentage of their energy from renewable sources.

If suppliers were also to pay for a Nuclear or Carbon Obligation to support nuclear power (discussed in next chapter), prices could rise, thus increasing the numbers of fuel poor. Furthermore, since a major factor in fuel poverty is the standard of housing and lack of adequate energy efficiency measures, any undermining of energy efficiency brought on by support for a new nuclear programme is likely to itself increase the numbers of fuel-poor. This could be politically sensitive, particularly as the 2003 Energy White Paper recognised energy efficiency as 'the cheapest, cleanest and safest way of addressing all our [energy policy] goals[46], well below the projected cost of nuclear power.

It also seems unlikely that new nuclear power stations will contribute much to the government's fourth energy policy goal of support, wherever possible, for competition and maintaining competitiveness. As discussed in the next chapter, support for nuclear power threatens to undermine many of the benefits of liberalisation and privatisation of the electricity industry as well as creating tensions with other pro-competition goals within energy. Moreover, nuclear power does not add much value in cross-overs to the cost-benefit analysis of future energy scenarios. It is very difficult to quantify these innovation and system benefits or costs in the long term[47], meaning that non-nuclear low carbon technologies do not get credit for the value they can add, and the lack of long-term value does not penalise nuclear power.

3.4 the importance of options and flexibility

Innovation and technological development are inherently uncertain processes. In the face of this uncertainty, it is desirable to keep options open to maintain flexibility and the ability to adapt to changing circumstances in the future[48]. To keep options open, innovation in a wide range of technologies has to be encouraged. The focus of

UK policy should therefore be to establish various new sources of energy, which are, or can be, low cost and low carbon[49].

Developing options will require support for innovation. In the context of the future energy system, this innovation will clearly involve generating technologies, but should also take into account innovation in infrastructure and institutions to allow new technologies to emerge and thrive.

Successful technological innovation is key to ensuring that the costs of abating carbon dioxide emissions are as low as possible[50]:

- Creating options or bringing them forward in time, improves the flexibility of policy, which all studies agree is key both to reducing costs and to winning public acceptance;

- Reducing uncertainties about the performance of a technology before it is turned on to a large scale increases the *options value* of a policy, and

- Reducing costs to future investors and consumers, and enabling environmental problems to be solved sooner has obvious financial benefits.

The value of maintaining flexibility almost self-evidently precludes committing to a new nuclear reactor programme. The inflexibility of such a large investment and construction programme would be exacerbated by policy makers' susceptibility to 'entrapment' when dealing with large investments, an issue highlighted by William Walker. He analyses the long-lasting political debate surrounding the Thermal Oxide Reprocessing Plant (THORP) at Sellafield: despite the collapse of the economic and technical justifications for operating the plant, the industry and government continued to press ahead with plans to open it[51].

In contrast, individual renewables projects do not entail the same degree of political or financial commitment. This is largely because of the difference in scale – projects of tens of MW do not require the same level of resources as a 1GW plant. It would therefore be easier to abandon a project if the economic or demand rationale for it evaporated. Pursuing smaller scale projects also keeps investment options open in an electricity market characterised by uncertainty about future conditions.

When a government considers developing new options, it must take account of the level and type of commitment required for each option. If the commitment level is considerably different, then any choice must take into account the effect of supporting one option over another. Developing a nuclear power programme is very different from a renewables/demand reduction programme. Treating them as complementary, or the same, effectively undermines renewable energy and energy efficiency options because the latter cannot be expected to compete against the political, financial and institutional commitments of the former.

The danger is that embarking on a nuclear programme will not only divert resources away from smaller-scale generating options, but once a construction programme has begun, the level of political and industry commitment means that it acquires a momentum of its own, and no amount of evidence exposing its costs will stop the project coming on line. In other words, if a decision is made to press ahead with a nuclear project, the project will be completed, and will, to a greater or lesser degree, lock the electricity system into a centralised model.

3.5 linking energy policy and sustainability

Nuclear power is generally perceived as an electricity-only technology, although it could provide heat if the power plants were sited near demand centres. As a result, nuclear power does not obviously link with other policy sectors. Renewables and demand reduction technologies do, on the whole, have these broader links, which can provide cross-over benefits.

There are three generally recognised areas which have to be addressed in order to move towards sustainable development: energy and environment; waste resources; and the agriculture and food sectors. In the context of energy, these sectors are linked:

- Heat and electricity can be an output from all three, for example, by growing crops for energy; using agricultural wastes for anaerobic digestion or burning; capturing landfill gas and improving resource productivity generally. As a result, any technological innovations in renewable generating technology can also impact on the waste resources sector and the agriculture sector, and vice versa[52].

- Through a cultural and behavioural mentality for sustainable action. For example, a family with a progressive attitude towards waste recycling is more likely to undertake energy efficiency actions, such as turning off lights.

In addition, there is a societal trend for individuals to take increased responsibility for their actions: for example, the focus on public health, and actions such as healthy eating as a preventative measure against certain diseases. This is analogous to energy efficiency measures; if energy is used more efficiently, less supply is needed.

One of the difficulties is that it is problematic to quantify the 'cross-over' benefits of a decentralised energy system in a conventional cost-benefit analysis, since they are unknown [53]. When bodies, such as the CBI, raise questions about whether reducing carbon emissions will hurt the UK's competitiveness, the answer is difficult to give.

The government's projected costs of moving to a 60 per cent cut in carbon dioxide emissions by 2050, a goal that underpinned the PIU Energy Review and the 2003 Energy White Paper, were more or less the same as keeping the current business-as-usual (BAU) high-carbon energy system going[54].

The real problem with dealing with the critiques such as the CBI's on competitiveness is complex:

- Firstly, the government has justified its move to a low carbon economy on the basis of a cost benefit analysis, but costs and benefits fifty years into the future cannot be known[55]. The government has to justify its policy based on the best cost-benefit analysis it can undertake at the time, even if it knows that there are flaws and uncertainties in the approach. As a result, a choice of policy based on cost benefit analysis is inevitably an easy target for those who wish to criticise it.

- Secondly, while the total costs over the fifty years may be about the same for the business-as-usual energy system as for a low carbon energy system, those costs do not fall equally over time. In a low carbon, non-nuclear energy system, large amounts of energy efficiency are projected early on, reducing the required energy capacity and hence the total cost of the low carbon energy system. The problem for government is that this represents a short-term cost, which will not reap benefits until the longer term. On the other hand, the nuclear scenario is almost the opposite, with higher total costs but spread across the fifty years with regular costs at the beginning leading to high costs at the end with decommissioning.

3.6 conclusions

As new nuclear power plants will not be on line until around 2018 at the earliest, they cannot contribute to the 2010 carbon reduction target and could at best make a very limited contribution to the 2020 target. Renewables and energy efficiency will be vital if those targets are to be met.

Future generating capacity depends on many factors. These factors mean that the development of the electricity system is extremely unclear beyond a timeframe of a couple of years. It also means that it cannot be known if future demand will exceed future capacity. Even if the concept of 'a generation gap' is understood in the way used by those arguing for nuclear power, new nuclear generation will only come on line after the majority of nuclear stations are currently scheduled to close, again meaning that nuclear power does not contribute to addressing the problem. Under this interpretation, avoiding any 'generation gap' up to about 2020 will depend instead on other generation and the successful implementation of demand reduction programmes.

Not only does nuclear power fail to offer the solution to climate change but this report argues that it will make it harder to address. Nuclear power cannot be the answer to the government's goal of energy security but risks accentuating our exposure. Similarly, it risks making the government's goal of eradicating fuel poverty and providing affordable energy even harder to achieve and is questionable in relation to the competitiveness goal.

4. what will it take to build new nuclear stations?

4.1 Introduction

What would the government need to do to ensure a new nuclear power programme could be delivered? What impact would these actions have on renewables, demand reduction and the transformation of our current energy system to a more sustainable one?

This chapter analyses the key areas that will have to be addressed to make nuclear power an attractive investment. It assesses the cost of nuclear power, explains the various risks involved in building a new nuclear power plant and looks at what has been done in Finland and the US to support nuclear power.

It is important to recognise that there are a range of different levels of support required, depending on whether the goal is one or two new nuclear stations or a full nuclear power programme. Different actors – in particular government and private companies – have different goals and therefore different requirements. An overarching framework to reduce risk in line with a goal of delivering ten new nuclear power stations would, in principle, be attractive to the industry. However, this is unlikely to be popular with the UK's incumbent energy companies, who have worked hard to carve out their market share. The government may therefore introduce measures which would stimulate a small number of new plants to be built by the incumbents.

The problem for government is that this will not give it certainty in achieving its carbon reduction targets.

4.2 The importance of risk

The generating cost of nuclear power is a central factor in determining whether or not it is supported. Certainly the issue has been emphasised by those advocating new nuclear stations, particularly in comparison with the costs of supporting renewable technologies[56]. However, in an absolute sense, generating cost is relatively unimportant once a decision has been taken to create a nuclear support programme, since the effort of getting stations built will essentially centre on supporting it in such a way that it is built, despite its costs. The cost of doing this for the UK taxpayer will be effectively open-ended, because limiting amounts or period of support would inject unacceptable risk into the investment.

The cost of the guarantees by government will largely be defined by the cost of constructing the reactor and managing its nuclear waste during operation and after closure. As can be seen from Table 2, there is no consensus about these costs, although past experience shows that nuclear companies substantially underestimate cost and a recent report for the Sustainable Development Commission called the possibility of appraisal optimism for nuclear projects in the UK a 'significant risk'[57].

The table does show, however, the degree of uncertainty about the costs of generating power from new design reactors, and also the extent to which estimates are dependent on key assumptions such as the project's operating lifetime and its load factor[58]. Load factor in particular is an important issue influencing the cost of electricity from the reactors and there is little evidence for the optimism of some studies that ninety per cent load factor will be achieved from untested reactor designs[59].

Table 2: Comparison of assumptions in recent forecasts for new nuclear power plants[60]

Forecast	Construction cost (£/kW)	Construction time (months)	Cost of capital (% real)	Load factor (%)	Non-fuel O&M (p/kWh)	Fuel cost (p/kWh)	Operating life (years)	Decommissioning schedule	Generating cost (p/kWh)
Sizewell B[61]	3,500	86	-	84	1.15	0.7	40	Part segregated, part cash flow	-
Rice University									5.0
Lappeenranta University	~1,300		5	91	05	0.2	60		1.6
Performance and Innovation Unit	<840	-	8 8 15	>80			30 15 15		2.31 2.83 3.79
Massachusetts Institute of Technology	1,111	60	11.5	85 75	0.83[62]	-	40 25		3.7 4.4
Royal Academy of Engineers	1,150	60	7.5	90	0.45	0.4	40	Included in construction	2.3
Chicago University	555 833 1,000	84	12.5	85	0.56	0.3	40	£195m	2.9 3.4 3.9
Canadian Nuclear Association	1,067	72	10	90	0.49	0.25	30	Fund (0.3p/kWh)	3.3
IEA/NEA	1,100-2,500	60-120	5 10	85	0.38-0.90	0.15-0.65	40	Included in construction cost	1.2-2.7 1.8-3.8
OXERA	1,625 first plant 1,150 later unit			95	0.35	0.3	40	£500m in fund after 40 years life	

4.3 reducing risks for investment

The Energy Minister, Malcolm Wicks, has claimed that any future nuclear industry would have to operate without heavy government subsidy[63]. Despite this optimism, it is more generally accepted that in order to attract investment to build new nuclear power stations, the government would have to provide both direct and indirect subsidies[64]. This is supported by a number of recent reviews of nuclear power as an investment option[65]. These subsidies would have to perform a range of functions:

- Provide appropriate rates of return expected by investors;
- Remove the risk of future political changes;
- Minimise the costs of financing construction debt;
- Ensure a market for the electricity when the station is finally commissioned;
- Guarantee in particular that the nuclear waste and decommissioning liabilities of the plant's operation would be minimised and/or capped[66].

If the government is to be confident that it can attract investment for one nuclear reactor, let alone a programme, it will have to reduce investment risk to the point that investors feel confident that they can be sure of a return whatever the changes in political parties and policies[67].

Any framework support mechanisms for new nuclear power will have to be acceptable under State Aid rules. This report has taken the view that government will be able to meet State Aid requirements. If it cannot meet such requirements, then it will be very difficult for a nuclear power programme to be established. Establishing what it can, or cannot do, in support of nuclear power therefore has to be a matter of urgency for government. Without such assurances, the construction of nuclear power plants has to be left to the commercial wisdom of companies, none of whom have so far brought forward plans to build plants, despite the theoretical ability to do so.

Government measures to reduce investment risk come at a cost, and the more risk is reduced the more costly it will be. In financial terms, risk would have to be reduced or removed in most if not all areas which could materially affect the return on investment. The extent and impact of these measures is unknown. Types of investment risk are set out in Box 3 below.

Box 3

Types of investment risk

- Possible delays or risks in gaining planning permission;
- Unexpected difficulties in construction leading to delays in commissioning;
- Escalations in the cost of waste management and decommissioning;
- Technology risks – for example, lower output than expected - and any technology licensing or other permitting concerns;

- Market risks;
- Revenue risks;
- The need to cap a nuclear operator's liabilities in the event of a catastrophic accident;
- Company risks (sale of company/takeover; strategy change; ability to sell nuclear stake);
- Capacity risk – the ability to deliver a programme of nuclear power plants;
- Political risk;
- Policy risk, and
- International political risk.

Investors in any new project have to be reasonably certain that they will realise an adequate rate of return on their outlay. The introduction of liberalisation and competition increases the risk that returns will not be sufficient to attract investment. Returns on investments in electricity utilities have been in the range of 7-12 per cent since privatisation[68]. The required rate of return for a new nuclear project is uncertain: one view is that because of the complex and long term nature of the risks associated with nuclear projects, the rate of return required to stimulate investment is more likely to be around 14-16 per cent[69]. Another view is that reducing risk would bring rates of return down towards the average figure.

British Energy's 2001 submission to the Performance and Innovation Unit's Energy Review, set out possible ways of providing this risk reduction[70]:

- A Carbon Free Obligation along the lines of the Renewables Obligation to accommodate 25 per cent of generation;
- The continuation of the Climate Change Levy, with nuclear power eligible for exemption;
- Carbon emissions trading or a carbon tax;
- A guaranteed, regulated return on capital to ensure that investors would have confidence they would see a return on their money;
- A streamlined consents process to ease the granting of operating licences by ensuring that there was a presumption throughout the construction phase that the project would be allowed to operate;
- A firm policy on nuclear waste management;

- Government involvement in construction, possibly through a Public Private Partnership, and

- Government underwriting for the construction period.

Subsequent studies or presentations have tended to repeat these requirements, but have in some cases added additional options, including:

- Long term supply contracts and increased support for training and R&D[71], and

- Guaranteed debt repayments or capital grants; accepting the waste liabilities; directly buying the output or even owning the enterprise[72].

These options are geared towards providing certainty for investors as well as giving direct, or indirect, operating subsidies to the industry. Even if only a few of these demands were set in place, it is clear that significant changes to the structure of the competitive electricity market would be needed to allow financing of new nuclear stations to maintain nuclear generation at around 20 per cent of the UK's requirements. This would exacerbate the indirect market distortions created by the open-ended subsidies already granted to the nuclear industry as a result of the bailout of British Energy[73].

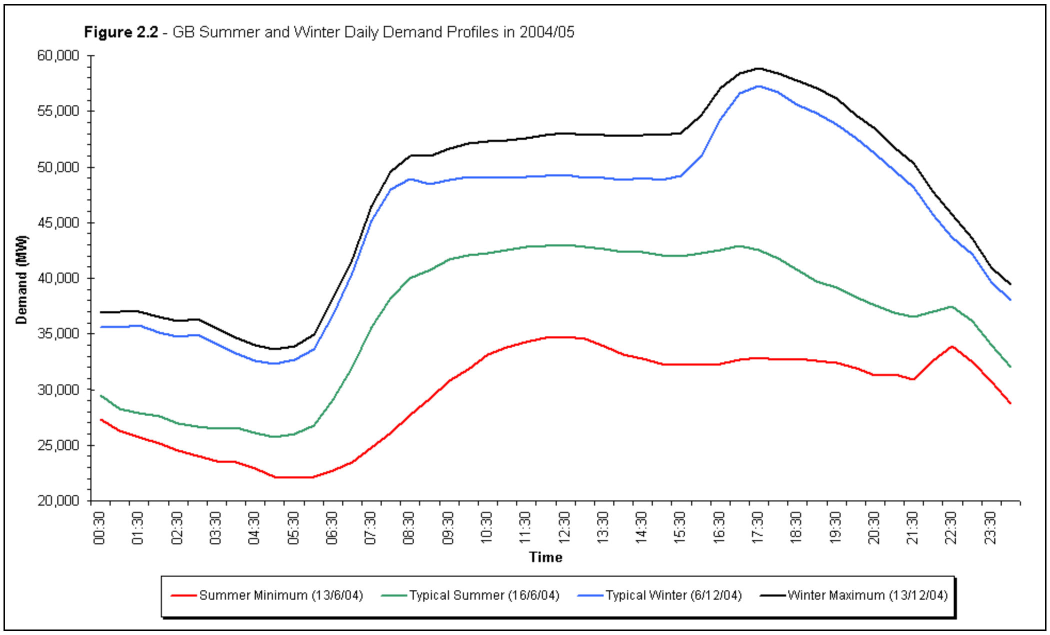
Whatever the combination of support mechanisms chosen, the government would effectively have to subsidise all stages of a nuclear reactor's life – construction, operation and the open-ended decommissioning and nuclear waste management phase after the plant was closed.

4.3.1 reducing market and revenue risk

Liberalised electricity markets have proven to be a difficult environment for nuclear power plants. This is because of nuclear power stations' long construction times, high construction costs, inflexibility in generation and uncertainty about the costs of dealing with nuclear waste - all of which add risk to a project. When compared to natural gas power plants which can be of almost any size, be constructed quickly, are flexible generators and cheaper, it is little wonder that a new nuclear power plant has not yet been built and operated in a liberalised electricity system[74].

Electricity systems operate in real time. In other words, at any given moment, the supply of electricity has to equal demand. The level of demand fluctuates according to the time of year and the time of day, with the peak occurring on a cold winter's weekday at around 5pm (see Figure 1). There is, however, a minimum amount of electricity which always has to be supplied, known as the base load.

Figure 1: GB daily demand profiles[75]



Nuclear power stations are inflexible generators as they are unable to follow the peaks and troughs of demand, and instead have to operate at a constant level of output. The reasons for this are partly technical: increasing and decreasing temperatures to adjust output causes thermal stresses which over time can lead to components cracking or even breaking. Repairing, or replacing degraded components would require the plant to be closed. Nuclear stations therefore supply base load power, leaving more flexible generators to 'load follow' as demand increases or decreases. By providing base load electricity, the generator is able to operate constantly at maximise output, thereby minimising the cost per kilowatt.

Given the high costs of nuclear projects, investors have to be confident that any nuclear station will be able to operate in the most cost effective way to provide certainty that they can finance their debts from the project's construction. Investors will therefore need to be confident that the government will ensure that market and revenue risk is removed so that the station's output can be sold at an acceptable price. This means that government must be prepared to underwrite, or guarantee, prices for new nuclear output through the market, either directly or indirectly, for several decades.

There is no guarantee that the capital and decommissioning costs of new build nuclear power plants will ensure that they are economic at base load, even if their generation costs are low. In order to ensure that they will be able to operate at base load, nuclear plants would need a range of support mechanisms, as outlined earlier, to:

- Bring the price per kWh down, either by subsidies or framework conditions, to a competitive level so that the plants can operate within the electricity market at base load;

- Ensure that bilateral contracts between the generator and suppliers guarantee buying all electricity produced, allowing plants to run all the time, even if this is more expensive than other base load electricity, or

- Directly alter the market to enable nuclear power to operate as a base load generator.

The fact that such a large proportion of electricity would be supported in an open-ended way would mean that the electricity market would reduce substantially in size. Competition in generation would therefore be reduced to a far smaller market.

The nuclear industry emphasises its role as a base load generator, but tends not to acknowledge the inevitability of this role given the technology's relative inflexibility. The point here is that by providing a high proportion of the UK's base load demand, the nuclear industry is denying other generators the opportunity to do so. This in turn will leave other generators with uncertain markets for their output, meaning that investors will be less confident of receiving a return on their investment in these areas and are therefore less likely to put their money in.

New reactor designs are theoretically more flexible than existing reactors currently operating on the UK system. Even if operators did decide to increase and reduce output in response to demand, this would have an adverse effect on the economics of the station. As pointed out earlier, load factor is an important element in the costs of power from reactors, and in order to achieve as low a cost as possible, operators will need to be operating the highest load factor possible for as much of the time as possible. While operating more flexibly may be technically feasible for new reactors, it will not be economically attractive.

In addition, it is solely market prices which are meant to prompt the correct workings of the electricity market, including providing incentives for new capacity. The ability of market prices to prompt appropriate capacity responses will be dulled if 30-40 per cent of the market is ring-fenced through obligations covering both renewable and nuclear output, and for base load generation. This is qualitatively different from ring-fencing renewables generation because renewables are projected to fall in price and become competitive. Nuclear power would have to be ring-fenced for the lifetime of the power plants, which is at least forty years.

The UK government is arguing for liberalisation, competition and transparency of prices in areas such as the international and European natural gas market. The success of privatisation and liberalisation has been the catalyst to making costs and prices more transparent, although those related to nuclear power still remain shrouded in uncertainty. A move towards less liberalisation, with such potential long-term consequences, is an extremely retrograde step.

4.3.2 political and policy risk

Given the considerable risks to government of supporting a nuclear power programme, investors will perceive there to be considerable political risk. A nuclear power plant will live through at least ten or a dozen parliamentary lifetimes, from discussion to decommissioning. There is a real risk that both policy and the political situation will change. Investors will require confidence that their investment can be recovered irrespective of this.

Investors will take the history of energy policy and nuclear power development in the UK into account when making decisions. In 1979, the then Conservative Government announced that there would be a programme to construct ten new reactors, with the construction of one reactor beginning each year from 1982[76]. In the event, only one was built, Sizewell B, which came on line in 1995. This was in a monopoly situation and should have been a far easier task than it would be to build nuclear reactors today with more technologies, more customer involvement and liberalisation. Subsequent white papers in 1995[77] and 2003 found against nuclear power on economics grounds. Within three years, another review is considering the question again. Given the controversy behind this review, investors must ask: 'how long will it be before energy policy is reviewed again?'

The risks to government fall into the following categories:

- Supporting a technology that may be found to be more expensive than renewables and demand reduction.

  The costs of different forms of electricity generation in 2020 are unknown. Projections behind the PIU Energy Review and the 2003 EWP showed that some renewable technologies were projected to be amongst the cheapest generating technologies by 2020, as their prices fell compared to gas. Some technologies (onshore and offshore wind, some biomass and possibly some wave) were projected to be cheaper than nuclear power[78].

- Getting 'locked-in' to a technology which may be expensive over the long-term; which does not contribute to government goals of sustainability, security and fuel poverty reduction; and whose success will take a long time to evaluate.

  Support for nuclear power will almost certainly have to cover all aspects of the project's life. While day-to-day generating costs may become competitive (e.g. because of increasing gas prices), nuclear would still require a surrounding package of support. In the event that individual renewable technologies do not become increasingly competitive, support for them can be curtailed relatively easily given the high number of small projects and the mixture of technologies. Support for a nuclear power programme is 'locked in' to a much greater degree, not only because of the time taken to construct and ascertain whether it is working or not, but also because of the need to provide support for dealing with the nuclear waste created.

- By supporting a mature technology, that is not projected to fall in price, the government is effectively jettisoning principles of public policy expenditure.

  The extent of support outlined above for new nuclear build is qualitatively different from support needed for a renewables programme, since support for renewables technologies is projected to decline as those technologies become competitive, in line with the principles of public policy investment. Public expenditure on technologies is generally aimed at stimulating innovation, developing options and is under the expectation of price falls. As far as possible, public money should not interfere with the direct functioning of the market unless part of a clear innovation policy.

- Announcing a review of energy policy so soon after the last Energy White Paper has focussed attention on the issue of political risk, thereby potentially undermining or delaying investment decisions while energy policy is effectively in limbo.

There is a very real risk that actions by the government to reshape the market will undermine investment, not just in renewables and demand reduction but also in natural gas heat and power plants. If a new nuclear programme did not perform, the UK's emissions reduction programme would be in serious trouble.

4.4 nuclear power and energy security

The underlying energy policy argument of the 2002 PIU Energy Review and the 2003 Energy White Paper was that natural gas would act as a transition fuel to a low carbon energy system. Its percentage of the market would gradually decrease until it assumes a role as a flexible 'balancer' on the system to complement intermittent electricity from renewables.

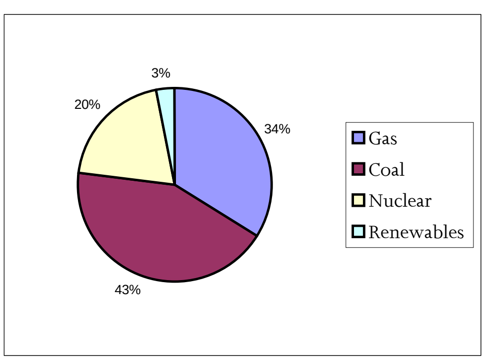
The past few months have seen concerns about the security of natural gas supplies[79] used as an argument for new nuclear plant build. For example, the CBI has voiced concerns that we are over-dependent on natural gas for electricity generation, domestic heating and industrial use and that renewables and demand reduction measures are not delivering fast enough to ensure that there is sufficient future capacity.

The CBI is keen to maintain energy security – meaning enough electricity and gas for the needs of its membership at an acceptable cost. As part of this, it argues for rapid clarification of the place of nuclear power in the energy mix and progression of supportive measures for nuclear[80].

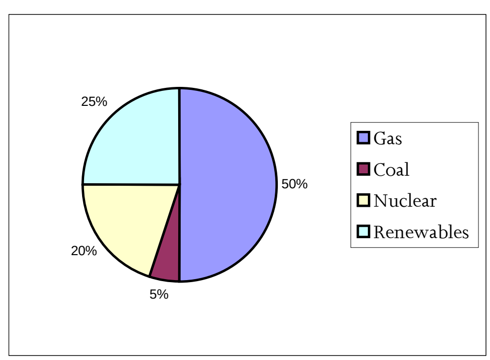
This is a very risky strategy for government. We have tried to illustrate this conceptually below.

Possible outcomes of support for a new nuclear power programme

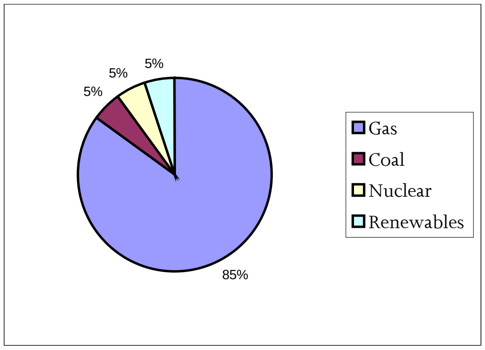
Current electricity generation



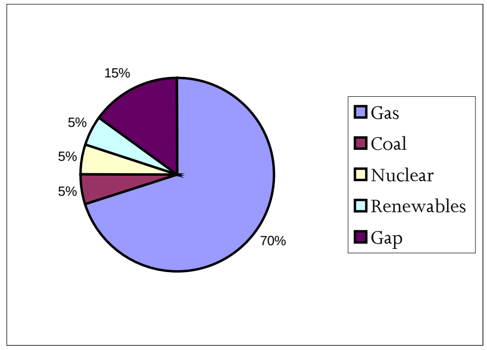
Scenario A



Scenario B



Scenario C



The first chart shows the current energy fuel mix for all electricity generation in the UK. The government argues that climate change is so important that all technologies need to be harnessed to combat it. This implicitly treats nuclear power as a complementary technology. Government would expect a successful programme to produce something like Scenario A (some more natural gas use, but not much more; a replaced nuclear programme and a lot more renewables).

But if nuclear power is not a complementary technology and will undermine the development of renewables and demand reduction, the outcome of supporting a nuclear power programme would be much more likely to result in Scenario B rather than A (far greater use of gas and very little extra renewables).

The worst scenario for government is Scenario C, where political risk is so high that not enough investment has occurred even in natural gas, causing major energy security problems.

The scenarios illustrate just how risky support for nuclear power may be for government. They may aim for Scenario A, but the risk is that they might end up with Scenarios B or C, far worse energy mixes, particularly in environment and security terms.

4.5 support options

As has been discussed above, the government would need to reduce investment risk in nuclear power by establishing a framework of support mechanisms.

This section analyses three different mechanisms which could support nuclear:

- Carbon Obligation;
- Nuclear Obligation;
- Recycled Taxation Fund or Carbon Contract.

4.5.1 carbon obligation

A broader technology-neutral Carbon Obligation has been suggested many times over the last decade, since discussions of what to do with the Non-Fossil Fuel Obligation (NFFO, the first mechanism to support renewables) got underway in 1997[81].

A Carbon Obligation would presumably be modelled along the lines of the Renewables Obligation (RO), which requires electricity suppliers to buy a proportion of their power from renewables generators. There are two ways that this could work, either alongside the RO or subsuming the RO within it. A Carbon Obligation would include all eligible low-carbon technologies, probably including nuclear power and other carbon abatement measures. It could also incorporate demand side measures. Expanding the obligation concept to all low-carbon sources would go some way to addressing the investment risk problem faced by developers of new nuclear reactors as it would provide some guarantee of a market.

This option is likely to be preferable to suppliers, since some of them may not wish to buy nuclear power and may find the ability to meet the obligation with a wider range of technologies preferable to a 'Nuclear Obligation', discussed below. However, if the Carbon Obligation subsumed the Renewables Obligation, renewable energy companies would find it more threatening (at least in the short term) than separate nuclear and renewable obligations, where at least individual technologies are ring-fenced.

Even if the Carbon Obligation was kept separate initially, the risk in the long term is that the Renewables Obligation would not be extended beyond 15 per cent and would be eventually subsumed into the Carbon Obligation. One way to ensure the credibility of the Renewables Obligation would be to give a commitment, before the establishment of a Carbon Obligation, that the RO would continue rising by 1 per cent a year, until it reached 27 per cent in 2027.

4.5.2 a nuclear obligation

Another option currently being considered as a means of providing some of the necessary support for the nuclear industry is a Nuclear Obligation[82]. This would probably be modelled along the lines of the Renewables Obligation but would run in parallel with it.

Assuming that a Nuclear Obligation (NO) would cover at least a replacement programme of around 20 per cent of electricity supply, the proportion of supply covered by an obligation would rise to 35 per cent (20 per cent plus15 per cent already covered by the Renewables Obligation). The risk for renewables developers is that, given the high level of the market to be covered by a nuclear obligation, there will be no further increases in the percentage obligation for renewable generation.

That the government would be prepared to underwrite such an obligation would send a very powerful message to the investment community of its support for nuclear power. In that situation, it would seem likely that the less well developed, riskier renewable technologies such as wave power, tidal stream, photovoltaic roof tiles, fuel cells and so on would find it even more difficult to attract investment.

However, although a Nuclear Obligation would reduce risk more effectively than a Carbon Obligation for nuclear investors, it would be more risky to government. If nuclear power plants were not commissioned, suppliers would have to pay a penalty. It would also require that all suppliers buy nuclear power, and many of them may not want to. They may prefer a Carbon Obligation so that they can choose their low-carbon source. For the renewable industry, a Nuclear Obligation alongside a Renewable Obligation would be preferable to a Carbon Obligation because they fear that, without ring-fencing, there would be a possibility that support for renewables would be subsumed within the Carbon Obligation, as described above.

The risk is, that if suppliers are unhappy with a Nuclear Obligation, there is more chance of a Carbon Obligation being established. Given the non-technological basis of the Carbon Obligation, there might be pressure to subsume the technological premise of the Renewables Obligation in the same way.

4.5.3 auctions of permits and carbon contracts

A recent article has proposed that tradable permits or long term carbon contracts could be auctioned to underpin public liabilities[83]. This mechanism could be linked to any sector (such as aviation) or narrowed, for example, for a nuclear fund. It is primarily an economic mechanism, although it does recognise, to a degree, that appropriate institutions have to be in place. Developing such a mechanism would take more work than either a Carbon or Nuclear Obligation since they are modelled on an existing system. In addition, such a mechanism would have to link with the EU Emissions Trading Scheme. Since it could be viewed as a hypothecated mechanism, there may be additional State Aid difficulties.

If a Carbon or Nuclear Obligation is put in place, the focus on establishing appropriate policies to encourage the further deployment of renewables and demand reduction would be undermined as the obligations would be expected to meet their targets. This would remove the impetus to devise further policy frameworks under which renewables or other low carbon options, including demand measures, could develop more.

4.6 new nuclear build: Finland and the US

Obtaining information about the requirements of a new nuclear programme is difficult because no nuclear power plants have been built and operated in a liberalised electricity system. However, the nuclear industry often cites the reactor in Finland as a model of nuclear construction in a liberalised market. The arguments used by the Finnish industry to justify the new construction of a 1600 MW reactor at Olkiluoto are remarkably similar to those used in the UK: the need to provide a secure supply of electricity and reduce future reliance on imports while meeting climate change commitments. Construction at Olkiluoto began in 2005 and it is due to begin operating in 2009.

However, the use of Olkiluoto as an exemplar fails to acknowledge the factors which make the new Finnish reactor unique. The reactor will be owned by TVO, a not-for profit utility owned by energy intensive Finnish industrial and power companies. TVO sells its electricity to its owners at cost[84]. This is an arrangement which is unlikely to occur in the UK. The outcome is that the owners are protected from the risks inherent in a liberalised market because they have a guaranteed market for the reactor's output.

In addition, there is some confusion about what the costs of the reactor will actually be. Reports put the costs of Olkiluoto at around €3 billion, although it has also been suggested that the French vendor, Framatome, is offering it at this price as a 'loss leader'[85]. There is no information available on what contractual arrangements exist between Framatome and TVO on risk sharing or who bears any cost overruns[86].

Areva, which is part of the consortium building the plant, will also be supported by a guarantee of over €610 million from the French export credit agency, COFACE, the first time such a guarantee has been put in place for an export within the EU[87]. COFACE would reimburse this sum to Areva if the project is abandoned or if TVO is unable to honour the contract.

4.7 the US Energy Policy Act

It is impossible to put a firm figure on the total subsidy cost for new nuclear build in the UK, as it depends both on future electricity prices and the degree of certainty required by investors. However, an indication is given by the US government's subsidy programme, set out in the Energy Policy Act 2005. The package includes underwriting or subsidies to cover the whole lifetime of projects; a framework to insulate the industry against regulatory and legal delays; research and development funding and assistance with historic decommissioning liabilities[88]. The main measures are set out in Table 3 below.

Table 3: Measures in the 2005 Energy Policy Act 2005 ($m)[89]

	Cost ($m)		Duration
R&D	1,432	Dept of Energy R&D programmes on new reactor technologies as well as reprocessing and transmutation	3 years
	149.7	Dept of Energy academic research and training programmes	3 years
	100	Demonstration projects for hydrogen production at existing reactors	
Construction subsidies	2,000	'Standby support' to insure the industry against delays in the construction or licensing of six new reactors. This would cover the full cost of delay for the first two reactors up to $500 m each), and 50% of the costs of delays to a further four reactors (up to $250 each).	First 6 reactors
	1,250	Funding of the prototype Next Generation Nuclear Plant in Idaho to produce nuclear electricity and hydrogen. Additional funds as necessary from 2016 – 2021	2006-15 (2016-21)

	~6,000 [90]	Loan guarantees for up to 80 per cent of the cost of a project. Covers 'innovative technologies', which includes advanced reactor designs	
Operating subsides		Reauthorisation of the Price Anderson Act, which caps the nuclear industry's liability in the event of an accident. The cap is set at $10 bn	Up to 2025
	5,700	Production tax credits of 1.8 cents/kWh for the first 6,000 MWh from new reactors for the first 8 years of their operation, subject to an annual limit of $215 m	2005-25?
Back end subsidies	1,300	Changes to the tax and legal status of some decommissioning funds	

4.8 demands on institutional resources

Institutional resources will be needed to ensure that framework mechanisms are put in place to deliver a programme of nuclear power plants. This might require changes to legislation, the merging or de-merging of different departmental responsibilities and certainly a large increase in civil servants, particularly if public opposition becomes pronounced. While preparing for a nuclear power programme, it will be necessary to focus even more strongly on the promotion of renewables and demand reduction to ensure that no undermining occurs.

Institutional resources will be needed in the following areas at least:

- Planning: Action to reduce the risk of long, costly nuclear plant planning applications and the speeding up, or changing, of licensing procedures. There could be significant opposition to this if the fundamental planning procedures of the UK are threatened.

- Regulation: Ofgem, the energy regulator, is responsible for regulating the energy system and works to Duties. These Duties would have to be changed if support for nuclear power was perceived to counter the current rules. More likely, providing there was no direct intervention in the market, Ofgem would be required to support the indirect developments and mechanisms of support via legislation.

Departmental resources: All the potential direct and indirect support mechanisms discussed previously, such as planning; insurance liabilities; waste and decommissioning agreements; development of obligations; new legislation and liaising with the EU on State Aid would have to be undertaken through various institutions and departments. All would require additional resources. These institutions would include the Office of the Deputy Prime Minister for planning questions; the Environment Agency; the Nuclear Installations Inspectorate and Ofgem. New nuclear build would therefore require extensive civil service resources, a considerable challenge, particularly following the recent drive to reduce the size of the civil service[91].

4.9 public acceptance

Public support has to be in place for the development of any new nuclear power stations. It has been such a long time since new nuclear power has been built that a large proportion of the population has never been involved in any public debate about its desirability or otherwise. Public support for nuclear power is very uncertain – a recent MORI poll for the Tyndall Centre found that a majority of the public would support the development of renewables and energy efficiency over new nuclear stations as an option for addressing the UK's carbon dioxide emissions[92].

4.10 conclusion

Putting in place a set of conditions to encourage investment in nuclear power would be a substantial commitment. It would require an unknown, open-ended commitment to support the technology to ensure that investors were insulated from the disadvantages of investing in this field. This would undo many of the moves to make electricity costs more transparent and could include ring fencing a portion of the electricity market to protect nuclear, an already developed technology. The experience of other countries supports the argument that stimulating a nuclear construction programme will require significant resources.

The knock-on effects of developing such a market would be significant for investors in other technologies, because much of the operating risk in the market would be shifted to new, non-nuclear projects. The situation could be particularly serious for developing technologies such as renewables, which rely on their lack of carbon emissions to attract investment. With the prospect of large quantities of nuclear generation scheduled to come on line in the future, the incentive to invest in new renewable technologies would be removed or, at best, watered down.

There would be considerable risks to the government in pursuing a new nuclear programme, largely because it would undermine investment in other technologies or low carbon options. In the short term, it would exacerbate the risk that the UK would not meet its carbon reduction targets. In the longer term, it would shore up the current energy system without addressing the wider challenges of climate change. Nuclear power would consume not only the bulk of the financial support available for energy technologies but also huge amounts of time and effort by government. This would limit the opening up of other relatively untried options, which fit better with the broader technological and cultural aims of shifting to a lower carbon, sustainable energy system.

5. conclusion

5.1 introduction

The previous chapters have argued that if the government wishes to deliver new nuclear power plants it will have to put in place a watertight risk reduction programme to attract sufficient investment. The arguments in support of a new nuclear programme are based on the implicit assumption that all low carbon technologies and options are complementary: in other words that there can be a thriving nuclear power sector and continued emphasis on centralised generation operating in harmony with energy efficiency, renewables and other low carbon technologies[93]. This report disagrees with this argument entirely.

5.2 nuclear power as an undermining, non-complementary technology

The resources brought together to support nuclear power will provide policy mechanisms to reduce risk and provide investor confidence. The mirror effect of this is that as resources support nuclear they undermine the development of a low carbon energy system, through a combination of:

- Undermining the institutional resources required for developing renewables and demand reduction. Existing institutional resources will become focused on putting the framework mechanisms for nuclear in place;

- Undermining the political resources required for delivering renewables and demand reduction. Political resources will be harnessed for (a) taking such a big decision and (b) ensuring its movement forward, given the possibility of severe opposition;

- Undermining the financial resources available for renewables and demand reduction, whether at a government level or for private investment;

- Undermining the resources related to developing the technological requirements of a low carbon energy system, and

- Undermining the development of a connected customer who takes more responsibility for his/her energy decisions, and who also may gain interest in wider sustainable development benefits such as recycling; using public transport and buying low food-mile food.

These factors combine to undermine the development of a low carbon energy system. Not only do they undermine the government's environmental goal within its energy policy but also increase the risk that the other goals - energy security, affordable energy and competitiveness - will also be undermined.

As no new nuclear programme is as yet underway, it is impossible to define conclusively the impacts that all these factors will have. However, the extent of the possible impacts is so serious that they need to be explicitly considered by policy makers. Far from nuclear power complementing a move to a low carbon energy system, it will undermine it on three levels: the technology level; the energy system level and the sustainable development level.

1. On a technology level: Options are not equal and the resources and commitment required by a new programme of nuclear power would inevitably undermine commitment to renewables and demand reduction policies.

Technology options require different financial, institutional, infrastructure and political commitments. In a world of limited resources, the scale of commitment required to deliver a new nuclear power programme would be so great that it would dwarf those available to renewables and energy efficiency. Even if additional resources were available for non-nuclear low carbon options, they would not be able to compete sufficiently with the strength of the resources behind nuclear power because of the underlying momentum of the energy system and the selection environment, as set out in Chapter 3.

2. On a system level: A centralised system incorporating nuclear power is not compatible with the aim of sustainable development. A shift to a decentralised system would correspond more with the aim of sustainability. However, such a shift will require commitment and clarity of purpose because new, low carbon technologies are effectively excluded in the UK's current electricity system. Setting up a framework to enable a new nuclear power programme would reinforce the conventional, centralised energy system and make it more difficult for a sustainable energy system to emerge.

3. On a broader level of sustainability and social change: Support for a large, remote technology with inherent security problems is the antithesis of technologies which connect with people. Nuclear power therefore undermines the move to increased customer awareness of energy decisions. This in turn undermines consumer links with wider sustainability issues and the cross-over benefits this brings.

A choice to provide support for a nuclear construction programme would fatally undermine both the government's credibility on its climate change targets, and also the attempts it has made so far to shift to a low carbon economy based on renewables and energy efficiency.

Again a comparison can be made with Finland. As with the UK, Finland's carbon dioxide emissions are rising[94]. The International Energy Agency highlights the risk that the expectation of carbon dioxide reductions coming from the operation of the new reactor may inhibit Finland's ability to meet its greenhouse gas reduction targets under Kyoto, or at least to meet them in an incremental and timely way, if the operation of the plant is in any way delayed[95]. The dangers of this are very real – only a year into the construction programme at Olkiluoto, TVO has confirmed that the project is already more than six months behind schedule[96].

Another dimension of this potential problem seems to be that the impetus to reduce emissions in advance of the Kyoto compliance period is undermined by the expectation that the required reductions will come from the nuclear plant[97]. This is because coal will continue to be used for generation until Olkiluoto comes on line, rather than being replaced by a mixture of gas generation, enhanced renewables and energy efficiency programmes. Importantly for this report, the political decision to commit to the Olkiluoto plant also appears to have undermined confidence in the future market for renewables generation[98], although the full impact of this will take several years to emerge.

In the context of the current energy review, any continued uncertainty about possible nuclear construction will only continue to undermine confidence in the government's commitment to reducing carbon dioxide emissions, and it should therefore rule out this possibility.

Supporting a new nuclear power programme should be delayed until other low carbon options are tried because:

- If they are successful then nuclear power will not be needed, and if unsuccessful then at least some innovatory benefits from developing new technologies are likely to have occurred;
- Other options could be pursued seriously rather than being doomed to under-achievement (or failure) because the system continues to be driven by large-scale centralised generation and does not complement smaller technologies or demand reduction;
- Renewables and/or demand reduction projects tend to be small-scale and can be built and assessed quickly: learning can occur, and failure quickly becomes obvious. Although there may be stranded assets, they will be miniscule compared to the cost of an unsuccessful nuclear power plant, and
- The policies are reversible, meaning that, on the whole, the technologies can be removed.

Any serious attempt at developing non-nuclear, low carbon options would have to include demand reduction, including looking at behavioural, domestic and transport issues and this would have beneficial effects in both energy and broader policy terms.

5.3 recommendations for energy policy

The previous chapters of this report have set out the context of the current energy policy debate (Chapter 1); the requirements of a sustainable energy system programme (Chapter 2); what such a new nuclear programme could provide (Chapter 3) and what it would take to get it going (Chapter 4). This concluding chapter has looked at how a new nuclear power programme would make it more difficult for the government to meet the challenges of reducing carbon dioxide emissions.

This chapter posits alternative recommendations for the way forward:

- The government has to recognise that a move to a sustainable energy system is complex and needs predictable and persistent policies; that political and regulatory institutions all have to be working together to deliver it and there must be real effort to try to remove barriers to it.
- The government has to recognise that it has to choose between a centralised and decentralised system, it cannot have both. While obviously it would be easier

not to have to make a choice, the government will have to take a position because of the undermining and non-complementary nature of nuclear power.

- The government must establish rules and mechanisms to support the emergence of a sustainable energy system; these must encompass the whole system approach.

  This requires not just support for renewable electricity technologies through the Renewables Obligation (preferably an expanded version which reduces its risk), but also incentives for non-electricity renewable energy. Moreover, there should be an additional feed-in type mechanism for domestic supply technologies and technologies under a certain size. This would reduce transaction costs for both supply companies and individuals, enable increased investment and enable new entrants to participate.

  Joined-up support is needed across departments for all mechanisms on demand reduction, especially involving new entrants. Real effort has to be made to move from a sales culture to a service culture and to enable energy companies to make money from reducing demand rather than through selling units of energy.

- Domestic and residential emissions also need to be addressed. One strand may be via more mechanisms for supply companies but it also has to be through behavioural change concerning personal consumption. There have to be increased incentives for the domestic sector. It is entirely wrong that supply companies can make money out of low carbon options while others, such as individuals, small businesses, domestic households, who want to take responsibility for their emissions and set out about to try and reduce them, are unable to do so.

- Although not dealt with in this report, it is clear that rising carbon dioxide emissions from transport also need to be addressed.

- The government should also recognise that there are cross-overs between energy and other sectors and maximise their synergies.

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