Energy Scenarios to 2020

Summary

This paper explores issues associated with energy policy based upon analyses of the supply and demand balances for five scenarios to 2020. The scenarios used are the four Foresight Scenarios used in our earlier work to 2050, plus a business as usual case. But the scenario divergence in 2020 is much less than in 2050. Although much energy supply and use equipment, apart from buildings, will be replaced by 2020, it is unlikely that radically new technology will have major impacts on energy supply or demand by then. Replacement will be largely with currently known technologies.

Energy demand in industry and for building heating is very likely to fall. Demand for electricity and transport fuels could increase or decrease, depending on the attention paid to energy efficiency. Gas will remain the dominant fuel for heating and oil for transport to 2020. Oil and gas demand could therefore rise or fall, depending on energy efficiency, transport sector changes and the use of gas in power generation. But in any event, the UK will remain highly dependent on oil and gas. Whilst the UK is currently self-sufficient in both fuels, changes in the output of the UKCS mean that, by 2020, a large import dependence is likely.

Major fuel switching is only likely in the power generation sector. 36GW of current power plant capacity will probably close by 2020. Changes in demand mean that 25 to 50 GW of new capacity will be needed. The required build rate itself is not a problem. Without market intervention, new capacity will be met primarily by gas, largely in CCGT stations. The share of gas in power generation might then rise as high as 75%.

However, this is not inevitable. An emphasis on diversity might lead to a role for nuclear power and/or coal, but these are likely to remain unattractive options in liberalised markets and both have environmental problems. Such an approach would require significant intervention. Alternatively, emphasis on sustainability will lead to expansion of (gas-fired) CHP and renewables. These could meet all the demands for new capacity, and the latter in particular would contribute to diversity. Both, especially renewables, will need continuing financial support if this is to be achieved and the costs of ambitious targets for 2020 need further investigation.

Carbon emissions are more likely to fall than rise, compared to 2000 levels, especially due to the Climate Change Programme measures already in place. However, any fall by 2020 will be slight without further measures to support energy efficiency and low carbon supply technologies. Only if these are prioritised will there be continuing significant reductions in emissions, in line with what would be needed to meet the Royal Commission on Environmental Pollution's suggested target of a 60% reduction by 2050.

Longer term goals will only be delivered with significant innovation in low carbon technology. In order to set clear signals that sustainable options are the priority, we

suggest that the Government should set targets for both renewables and CHP in 2020. One option would be a joint (aspirational) target, though this needs further study.

We conclude that no other pressing decisions are required about new generating capacity. However, given longer term carbon reduction and energy security goals, it is important that Government gives increased attention to energy efficiency and to reinvigorating the existing commitment to the CHP and renewables targets for 2010. Delivering these goals will require early attention both to the disincentives in network regulation and the impacts of NETA on distributed generation. Insurance against the failure of these options to deliver in full can be provided by keeping open options for fossil fuels with carbon sequestration and nuclear power. Apart from the demonstration of carbon sequestration these options do not need early support to provide this insurance.

Introduction

1. The aim of this paper is to explore the range of issues associated with energy policy based upon analyses of the supply and demand balances for five scenarios to 2020. The work builds upon the analyses carried out for 2050. The focus of the present study is to explore the policy issues that would arise under the contexts associated with a business-as-usual (BAU) projection and the four Foresight Scenarios. The five cases considered are not forecasts, nor are they a set of exclusive choices. By following through the implications of the five cases different issues regarding supply and demand arise. The diagram below indicates the way in which the five scenarios cover a part of the spectrum of possibilities.

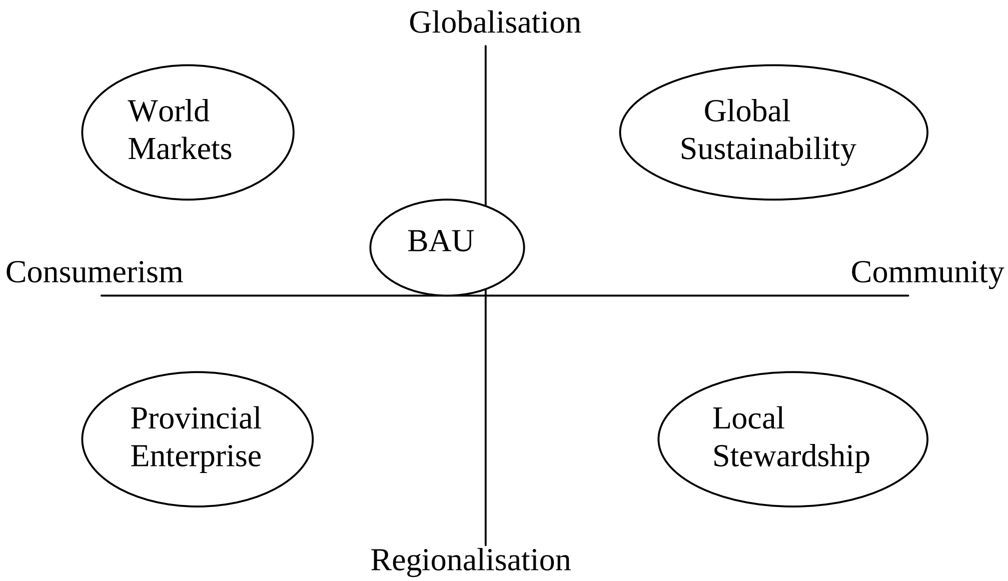

Figure 1. Locating the five scenarios on the grid of governance and social values

2. In terms of demand for energy services, the period to 2020 has very different characteristics than those projected for 2020-2050. Until 2020 the UK population is forecast to increase (from 60m to 63.6m). The Foresight scenarios have different population assumptions after 2020, but they all involve either a stabilisation or a decrease by 2050. Thus up to 2020 there is a steady demand for new homes, schools, retail outlets and so on with concomitant increases in demands for heating, lighting and power. From 2020 to 2050 new house building is assumed to replace the worst of the existing stock and in most sectors the capital stock does not grow but has its energy efficiency improved at each replacement.
3. From an energy supply perspective 2020 is beyond current planning horizons[1] and is well outside the range of reliable forecasts for fuel prices. However about half of the current UK generating capacity will need to be replaced by 2020. In Energy Paper 68 (CL case) 18GW of coal fired, 2GW of oil fired, 7GW of dual fired and 9GW of

[1] The period required for planning and building new power stations is typically 2-5 years for CCGT and renewables and 5 – 13 for coal and nuclear.

nuclear capacity will have been retired, a total of 36GW. One of the key aims of this analysis is to explore the overall effects, in terms of primary fuel mix and infrastructure requirements, of the different replacement strategies that could be expected under the different scenarios.

4. It is also unlikely that there will be any radically new technology introduced into the energy supply or demand system by 2020. Several technologies currently in the research and development stage may well be starting to make a contribution, for example fuel cells, however their main impact is expected to be in the period after 2020. This means that up to 2020 the main source of variety is in the choices made between currently known alternatives; after 2020 it is progressively more likely that new technologies will expand and modify the impact of choices on both the supply and demand side.
5. It is anticipated that over the next decade the UK will cease to be self-sufficient in gas and oil. This increases the range of issues associated with security of supply for UK energy policy.

The Scenarios

6. The Foresight scenarios have been documented[2] and previously analysed as part of the PIU project[3]. The following summarises the main features of each of the scenarios considered in terms of the energy demand and supply analyses. In all cases, by 2020 we assume that petroleum will be the dominant transport fuel and that gas will play a dominant role in the provision of heat. Analysis of supply side issues therefore concentrates on the electricity sector.
7. **World Markets (WM).** The core value is consumerist. This has the highest rate of UK GDP growth (3% pa) and the lowest fuel prices. Economic growth is rapid in this scenario and electricity demand grows most rapidly. The main drivers for technology development are cost, power quality and efficiency. Environmental drivers are not strong and the adoption of energy efficiency improvements is slow. Security of supply concerns are addressed through expanded gas and electricity interconnection, increasing decentralisation of power generation, with effective world trade rules, liberalisation of gas and power on the continent and good trading relations ameliorating geopolitical concerns about gas dependence. The high level of economic growth and limited environmental concern lead demand for road transport to grow rapidly. Air travel growth is particularly strong. The renewables obligation is frozen at 10%. This is comfortably met by on and offshore wind and eligible wastes. Nuclear power and coal are unable to compete with CCGT and the contribution of both runs down as stations come to the end of their lives.
8. **Provincial Enterprise (PE)**. The core value is individualist. UK GDP growth is assumed to be 1.5% and fossil fuel prices are high. Energy efficiency is limited due to lower capital availability and the low priority attached to environmental concern. There is very little investment in new public transport infrastructure, so despite lower growth, car and goods vehicle use continues to grow. Security of supply is the main

---

[2] See for example "Environmental Futures", Office of Science and Technology http://www.foresight.gov.uk

[3] See 'Energy Systems in 2050', paper presented to the 2nd Advisory Group meeting.

driver in this low-growth, low-innovation scenario. Concerns about excessive dependency on imported gas in a volatile world dominated by national interests ensure that both nuclear and coal stations are replaced. Environmental concerns are limited to issues of local and national amenity. The electricity supply mix reflects a 'quota' system for coal, nuclear and gas. The contribution from renewables is frozen at the 10% level achieved around 2010 as scarce capital is invested in replacement and refurbishment of coal and nuclear stations. Nuclear stations are large plants built on existing sites based on 'evolutionary' designs such as the Westinghouse AP series, coal stations are super-critical pulverised coal designs of UK origin. All new coal stations are fitted with FGD and low-NO_x emission control.

9. **Global Sustainability (GS)**. The core value is sustainable development. GDP growth is assumed to be 2% pa. Strong international agreements on carbon abatement lead to high priority being given to both energy efficiency improvements and the rapid development and deployment of renewables and CHP. International commitments 'beyond Kyoto' are comfortably met and the UK becomes a net exporter of carbon permits. Geopolitical concerns relating to security of supply are not a major concern in this world of strong international co-operation. Major investment in public transport infrastructure and changes to public attitudes result in slower growth in road transport use and more rapid innovation in transport technology. Renewable generation expands to 30% of total electricity supply. The largest single area of growth is offshore wind, followed by energy crops and biomass wastes, then onshore wind. Wave and tidal stream begin to make a contribution around 2015 and there is a small contribution from micro-hydro. Existing large hydro stations are refurbished as required and their contribution remains at 2000 levels. Nuclear and coal stations continue to the end of their lifetimes and are not replaced. After 2010 new CCGT stations are fitted with CO_2 capture and sequestration technologies.
10. **Local Stewardship (LS).** The core value is conservation and this has the lowest GDP growth rate of 1% pa. Over-riding priority is given to maximising utilisation of local resources with minimal environmental impacts. Consequently energy efficiency measures are given a high priority. A 'think global act local' environmental policy driver reduces import dependency. Very significant changes in attitudes to mobility stabilise the level of private road transport and increase the uses of trains and buses. Renewable generation expands to 20% of electricity supply. Onshore wind makes the largest single contribution as community owned turbines and plants become ubiquitous. Capital constraints and the increased focus on localised resources limit the contribution of offshore wind. Lack of investment in international R&D reduces the development of PV, wave and tidal. Solar water heating and micro-hydro are deployed to their maximum potential and biomass fired CHP is more widely used in rural areas. Nuclear power stations are not replaced as they are decommissioned but some coal fired stations are replaced or repowered, with CO_2 capture and sequestration.
11. **Business as Usual (BAU).** The assumed GDP growth rate is 2.25% p.a. In this scenario there is no overriding policy driver, instead the tensions between social, economic and environmental concerns continues. Transport trends continue with car use rising, but at a declining rate. Goods vehicle use grows more rapidly than car use. It is assumed that markets determine investment and that this leads to a growing

dependence on gas, particularly in electricity generation where renewables do not progress beyond the 10% target reached shortly after 2010. The scenario is based upon the projections of the Inter-Departmental Analysts Group on Low Carbon Options, which take account of the existing Climate Change Programme. The electricity mix is based upon the CL option in Energy Paper 68.

12. It should be emphasised that none of the above scenarios are predictions of what might or should occur. They are self-consistent snap shots that enable the shape of the energy system to be defined clearly enough for the major policy issues to emerge.

Energy Demand

13. The demand projections are illustrated in Figure 2. Demand for heat is lower than in 2000 in all cases, but power demand increases in all cases except LS. The increase in electricity demand is from 380 TWh in 2000 to 490 (BAU), 525 (WM) 440 (PE) and 390 (GS); the figure for LS is 342 TWh. The next section outlines how the electricity system develops in response.

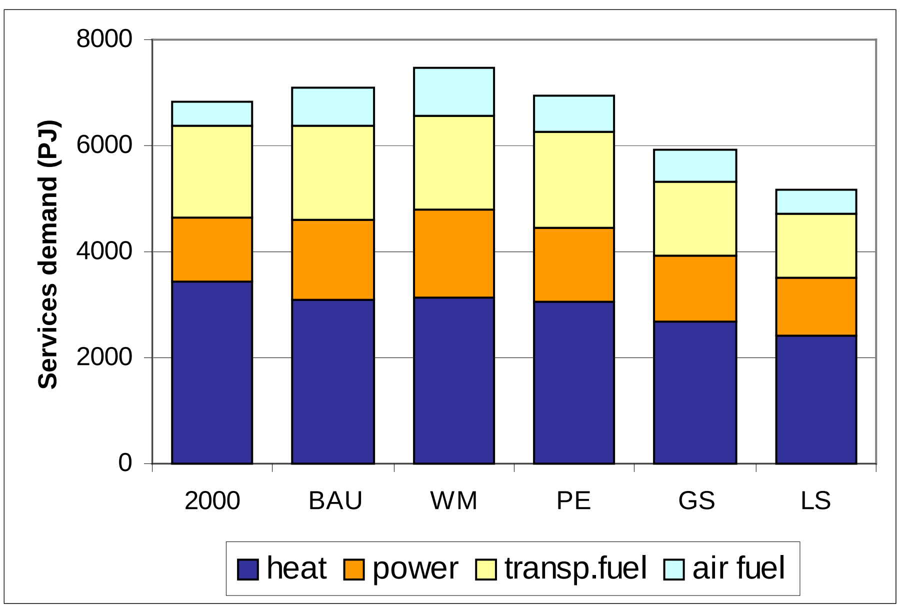

Figure 2. Demand for energy in the scenarios compared to 2000

14. Under business as usual, WM and PE scenarios, road transport fuel use changes little, in line with current trends. Growth in travel at approximately 2% annually is offset by a similar improvement in efficiency. This is largely driven by the agreement between vehicle manufacturers and the European Union to reduce average new car emissions to 140 g/km by 2008.

15. In the GS and LS scenarios emissions are lower, due to very much lower demand in LS and greater use of advanced hybrid vehicles in GS. This can be achieved without the use of fuel cell vehicles, which might begin to have an impact by 2020.

16. Air transport fuel use follows a different trend. In recent years the rate of growth of air travel has been double the rate of economic growth. Growth in fuel use has been moderated to some extent by improved aircraft efficiency. However, fuel efficiency

is already a high priority in aviation and radical improvements by 2020 are unlikely. In the LS scenario we project a broadly constant demand, but in the other scenarios growth of 30%-100%. In the highest growth scenario (WM), aviation fuel demand reaches a level of more than half of road fuel use and is still on a strong upward trend.

17. The demands for energy services in buildings have been estimated using the same models and procedures as developed for the 2050 analyses[4]. These use number of domestic households and commercial sector floor space as the primary indicators of energy service demands.
18. Another issue in forecasting demand for energy services concerns the degree to which demands can be assumed to have saturated. For example domestic average internal temperatures have increased from 13°C in 1970 to 17.5°C in 2000 and are expected to saturate around 21°C. By 2020 demand is still increasing due to increases in levels of service (higher temperatures, more hot water, more lighting etc) whereas by 2050 all these basic service demands are assumed to have been saturated

Electricity System

19. The mix of generation for the electricity systems projected for each scenario, under the assumptions set out above, are shown in Figure 3. Figure 4 shows the equivalent picture in terms of generating capacity.

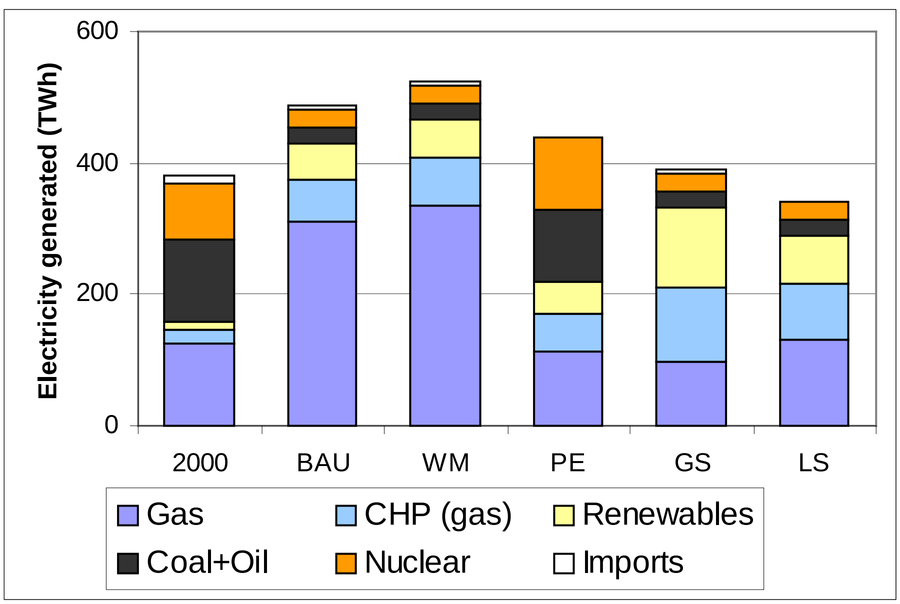

Figure 3. The electricity generated by fuel used

[4] See ‘Energy Systems in 2050’ presented to 2nd Advisory Board meeting

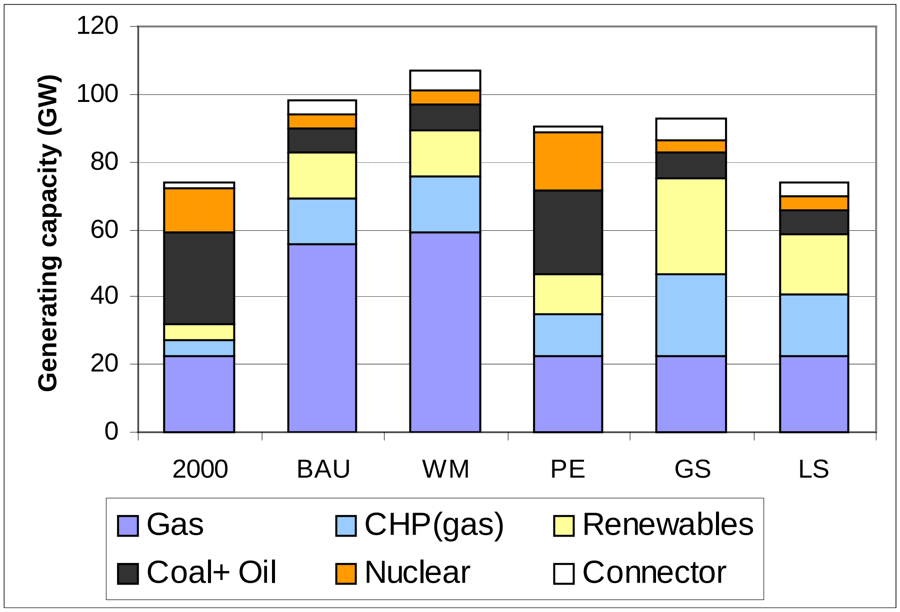

Figure 4. The generating capacity in each scenario

20. As expected, all scenarios involve the construction of significant new power generation capacity. In BAU this is approximately 50 GW (36GW replacement plus additional capacity required). However, this can be reduced significantly by demand side measures. Relative to this baseline, in LS there is a 25 GW reduction. A more feasible target might be the 15 GW achieved in GS. The different ways in which the different scenarios assemble the necessary generating capacity is indicated is illustrated in Figure 5. Note that the differences in demand are represented here as equivalent differences in capacity requirements.
21. These results show that only the PE scenario achieves a broad fuel mix with gas providing a high proportion of total electricity in all the other scenarios. In this scenario, the new capacity includes 12GW of nuclear and 18GW of new coal capacity. In BAU and WM the new capacity is largely CCGT with additions of 33GW in BAU and 37GW in WM. In both the GS and LS scenarios, all new capacity demands are met with gas CHP and renewables. In the LS scenario, the much reduced demand makes this relatively easy, but the demand reduction itself is ambitious. In the GS scenario the main issue is whether the necessary renewables capacity (approximately 14GW dnc) can be constructed in time at an acceptable cost. More work is needed on this issue.

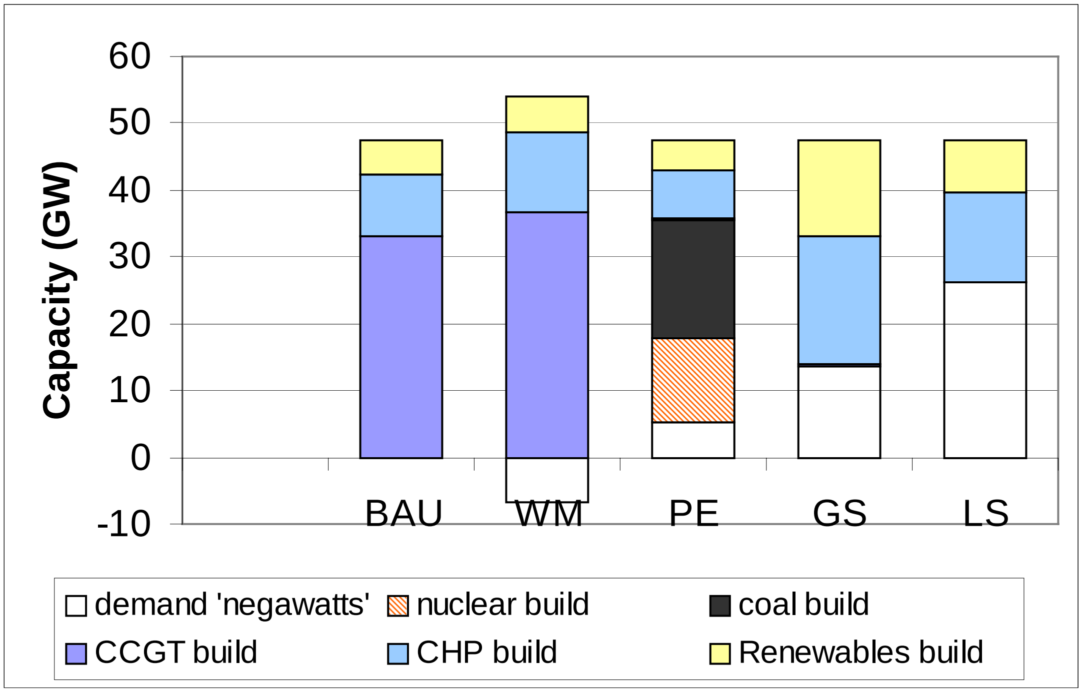

Figure 5. The ways in which the different scenarios meet the need for additional generating capacity by 2020

22. The main issue for the electricity distribution system infrastructure is concerned with embedded generation to facilitate the adoption of renewables and CHP, especially micro-CHP. Note that in the scenarios where micro-CHP is significant, its eventual contribution could be much larger as it captures more market share (up to 30GW). If fuel-cell units replace the current Stirling engines then the electrical efficiency will increase giving a much greater installed capacity (up to 50GW) and output (70 to 100TWh). More details on the projections for CHP are given in Appendix 1.
23. In the GS scenario, the electricity transmission system would need to be enhanced to accommodate a significant off-shore renewables contribution. In other scenarios, assuming that any new coal and nuclear plants are built on existing sites and that CCGT can be located close to demand these will not require significant expansion of the transmission system.
24. NGC is negotiating inter-connectors with Norway, Ireland and Holland. This, coupled with the existing French inter-connector, could increase the capacity for imports. This has not been included in any scenarios on the grounds that the main benefit from such interconnections are likely to be security of supply rather than high levels of import or export[5].
25. NGC have indicated that they would not incur any additional balancing costs whilst the contribution from intermittent renewables is less than 20% of peak demand. This is the case in all scenarios, except perhaps GS where the precise source mix, particularly between wind and biomass will determine the intermittent fraction. With

[5] The inter-connectors connect liberalised electricity markets that are largely subject to the same fossil fuel prices, so there are no grounds for expecting big net transfers. This may change if the markets develop significantly different fuel mixes (e.g. larger or smaller renewables components)

an intermittent contribution greater than 20% the system could be balanced by having a larger spinning reserve and more storage, for example Regenesys[6] or pumped storage.

Primary Fuel Mix

26. The overall primary fuel[7] mix for the different scenarios is illustrated in Figure 6. The importance of gas in all the scenarios remains high since it is assumed to provide a large proportion of the heating required as well as its contribution to the electricity system described above. The dominant use of oil is in transport with only a small component used for heating.

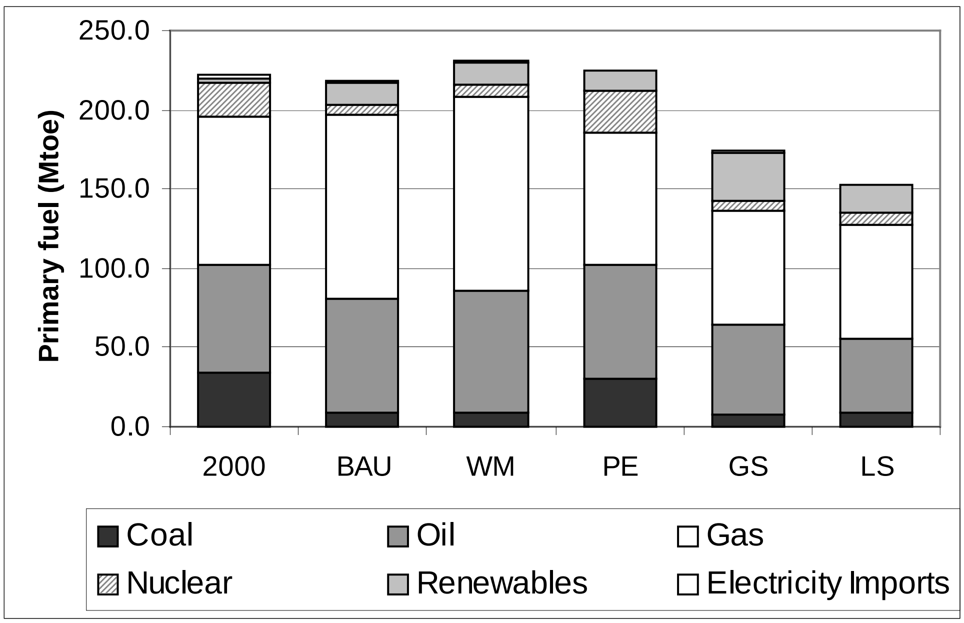

Figure 6. Primary fuel mix by scenario

27. It is clear from these results that in all scenarios the UK remains highly dependent on oil and gas. This is significant because whilst currently self-sufficient in both fuels the UK will need to import a large fraction of its requirements for both fuels by 2020.

Carbon Emissions

28. To complete the analysis of the scenarios Figure 7 below shows the carbon emissions corresponding to the fuel uses documented above. This shows that in the GS and LS

---

[6] This is a regenerative fuel cell that stores and releases electrical energy by means of a reversible electrochemical reaction between two salt solution electrolytes. The power handling capacity is determined by electrode design and the energy storage by the volume of electrolyte.
[7] Note that following the usual convention the nuclear and renewables contributions are counted on a thermal equivalent basis. The electrical output is divided by an average thermal efficiency to give the equivalent fuel input.

scenarios there are continuing significant reductions in carbon emissions, in line with what would be needed to meet the Royal Commission on Environmental Pollution's suggested target of a 60% reduction from current levels by 2050.

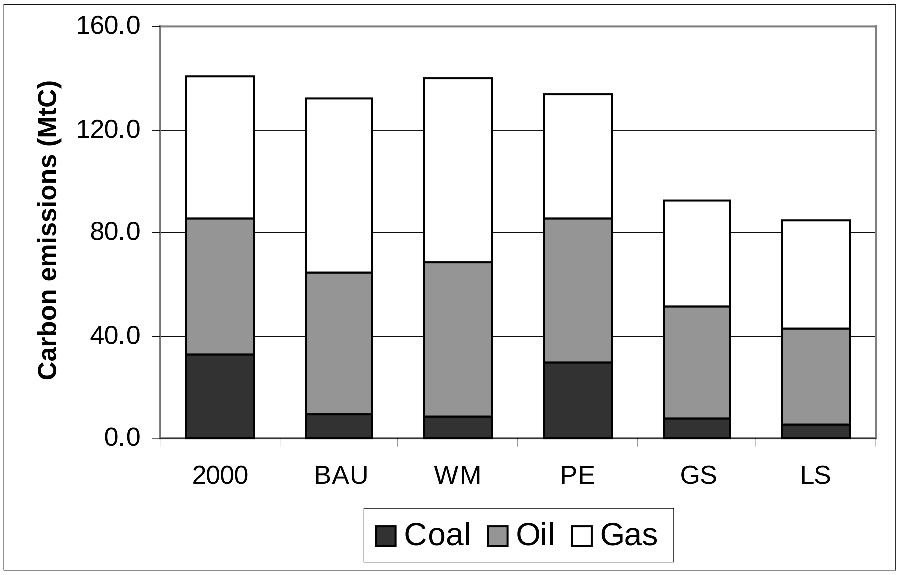

Figure 7. Carbon emissions for the scenarios

Emerging Policy Issues

29. There are a number of strong and important commonalties between all the scenarios analysed, it seems safe to assume that these will apply under a wide range of conditions. They are;
    - 29.1. Transport is likely to continue to be highly dependent on (increasingly imported) oil
    - 29.2. Provision of heating services will become more dependent upon (increasingly imported) gas
    - 29.3. The UK needs to build between 25 and 50GW of new generating capacity between now and 2020.
30. In all the scenarios, there is a substantial requirement for gas for heating and power generation. Demand could rise up to 30%, but with policy support for diversity and environmental goals could be reduced 10% or more. With expected trends in the UKCS, this will mean increasing import dependence in all scenarios. For the provision of heat the best options for reducing (overall) gas dependency are increased energy efficiency and adoption of CHP.
31. The potential for conventional and micro-CHP is significant in all scenarios and has a much larger longer term potential. In particular it provides a low cost way of increasing generating capacity and, in the case of micro-CHP, reduces gas consumption compared to current boilers[8]. In order to facilitate this potential it will be

[8] The average efficiency of domestic boilers is about 65%. A micro-CHP unit has a heat efficiency of 75% and an additional electrical efficiency of 15%, achieving the same overall efficiency as condensing boilers.

necessary to resolve the issues associated with embedded generation and the financial difficulties that have arisen as a result of NETA.

32. All scenarios require significant power station building, although there is a significant variation in the level. The construction of 40 to 50GW of new generating capacity over the next 20 years is not of itself problematic. In the 1990's NGC connected 2GW of new capacity per year (and decommissioned an equivalent amount of old plant). The major issue is the mix of plant to be built.
    - 32.1. If left to the market the new capacity is likely to be dominated by CCGT since this provides the lowest cost and lowest risk option. Even if natural gas prices increase it will remain attractive due to its low capital costs and modular construction.
    - 32.2. Provided the issues identified in paragraph 32 are resolved then the market may also provide significant CHP capacity, as the growth in the late 1990's demonstrated. The technology is cost-effective under most conditions of future gas and electricity prices but may also require policy support.
    - 32.3. Renewable capacity will require both financial support through the Renewables Obligation and other measures to meet the 10% target by 2010 and these will need to continue if renewables are to increase their contribution after that date. Some of the difficulties are the same as those faced by CHP (embedded generation and NETA).
    - 32.4. Coal and nuclear stations are unattractive in liberalised markets because they have long lead times and high capital costs and are both subject to significant future risks[9]. These are related to environmental problems. In the case of coal, long term environmental acceptability almost certainly depends on the development and use of carbon sequestration. It is therefore likely that both coal and nuclear would require subsidy/support/regulation to be adopted on a significant scale.
33. Transport sector energy demands may lead to an increase in required generating capacity if there is a shift from oil to electric or hydrogen powered vehicles. However it is unlikely that such a shift will occur on a significant scale before 2020. As a result, policy to deliver fuel security and environmental goals in this sector should focus upon energy efficiency and transport demand reductions to 2020 and the development of alternatives for the longer term.
34. Demand reduction can reduce the new capacity requirement substantially. This can substantially ease concerns about both energy security and emissions, but will require Government action. For new supply, the choice is therefore between either allowing the market to choose or intervening to support one or more of the renewable, coal and nuclear options. The case for intervening at all could be based upon
    - 34.1. Security of supply issues requiring more diversity. Although there may be adequate gas reserves, having an electricity systems with 75% of electricity being generated from gas may be too high a risk.
    - 34.2. Anticipation of higher future carbon abatement standards. Since the capacity being built between now and 2020 will generally last well beyond 2020,

[9] For coal the risk is higher environmental standards, for nuclear it is higher safety standards. There are also failure risks, including failures outside the UK. For example the failure of a carbon sequestration store or of a nuclear station elsewhere could jeopardise a UK investment.

there is an implicit commitment to the level of carbon emissions associated with those stations[10].

34.3. With the lead times involved, any government intervention to influence new generating capacity can be left to 2005. If the nuclear option is eliminated, for whatever reason, then the decision could be left even later since the other options have shorter lead times.

35. In all scenarios, there will be a increase in embedded generation. However, the level may be constrained by institutional factors, notably NETA and the treatment of embedded generators in the distribution networks. Addressing these problems is important for all energy policy goals. In the environmentally sustainable scenarios, there is also likely to be a need for electricity system development to accommodate offshore wind. Otherwise, electricity and gas transmission systems will need to develop in proportion to demand, but no radical shifts are required by 2020.
36. There are pressing decisions concerned with increasing attention to energy efficiency and reinvigorating the commitment to the CHP and renewables targets for 2010. Meeting those would reduce the pressure on other building decisions, provide added low carbon generating capacity and make the costs of (at least) these options clearer.
37. Longer term goals will only be delivered with significant innovation in low carbon technology, in particularly for end use efficiency, micro-CHP, higher cost renewable energy options and, possibly, carbon sequestration.
38. Our scenarios for 2020 indicate a range of possible outcomes for the combined output of renewables and CHP – stretching from 25% if no encouragement is provided post 2010, to 60% with optimistic projections of technical improvement and strong policy support.
39. Our overall conclusion for the new capacity in the electricity supply sector by 2020 is that it can best be delivered, consistent with all energy policy objectives, using energy efficiency, CHP and renewable energy, provided that the last of these can be built at acceptable cost. This approach will require rapid action to ensure fair treatment of these options in distribution networks and NETA. Insurance against the failure of these options to deliver in full can be provided by keeping open options for fossil fuels with carbon sequestration and nuclear power. However, apart from the demonstration of carbon sequestration these options do not need early support to provide this insurance.

[10] This suggests that we should consider, or require the market to consider, the relative long term costs of CCGT with sequestration, nuclear and renewables.

Appendix 1. CHP Capacity for 2020

1. The UK currently has 4.6 GW(e) CHP capacity spread over 1556 schemes. In 2000 these units generated 23.3 TWh of electricity and 61.5 TWh of heat with an overall energy efficiency of 71% (and load factor of 57.4%). The average electrical efficiency was 19.5% and average heat efficiency 51.6%.
2. The information in DUKES (Chapter 6) indicates that although there is an additional 3.2GW(e) of schemes that have been granted or applied for consent, only a few of these are likely to be commissioned in the near future due to changes in "market conditions". In particular the high price of gas and the low price available for CHP electricity under NETA. Assuming that "market conditions" are restored then the additional 3.2GW(e) of capacity could be expected to come on-stream from 2005.
3. The 1997 review of CHP potential (to 2010) indicated a range from 10GWe to 16.8GW(e) with the central estimate at 14.7GW(e). These estimates do not include any contribution from domestic or micro-CHP. Increases in potential capacity will depend upon technical progress, government policy[11] and the relative prices of gas and electricity.
   - 3.1. The modelling work undertaken by Paul Ekins using the Cambridge Model (MDM-E3) indicate that installed capacity is likely to be 6.6GW(e) in 2010 and 8.6GW(e) by 2020, both figures well short of the government's target of 10GW(e) by 2010.
   - 3.2. With full exemption from the CCL and regulatory requirements on CHP capacity the same modelling work produces capacities of 10.1GW(e) in 2010 and 19.7GW(e) by 2020.
4. Separate PIU analysis of micro-CHP has indicated that it has a significant potential in the domestic and SME sectors increasing steadily from 2010 to 2050. The technology is currently undergoing commercial trials and requires changes in approval and connection to be able to enter the market in volume. Assuming that the regulatory and embedded generation issues are resolved by 2003/4 then the potential contribution by 2020 is between 2.8GW(e) and 5.3GW(e) in the domestic sector[12]. The contribution in the SME sector is harder to estimate but is in the range 0.5GW(e) to 1.0GW(e)[13].
   - 4.1. At present replacing an older boiler with a micro-CHP unit *reduces* gas consumption as well as producing electricity. This arises because the micro-CHP unit achieves overall efficiencies of 90%[14], of which 15% is electricity and 75%

---

[11] In particular any carbon tax or preferential treatment for CHP output – as for example its exemption under the CCL.
[12] These estimates have been based upon analysis of the rate at which the technology substitutes in the boiler replacement market (dependent on price differentials) and a detailed model of the UK housing stock taking into account changes in population and energy efficiency.
[13] Large commercial buildings are included in the ETSU and Ekins forecasts of potential. Micro-CHP is only really suitable for domestic scale buildings, so there is a gap in scale which leaves part of the commercial sector unprovided with CHP facilities.
[14] The units include a condensing heat-exchanger.

heat. The average efficiency of the stock of existing boilers is about 65%[15] and the older ones being replaced have lower than average efficiencies.

4.2. Current predictions are that the units will cost £600 more than a replacement boiler. The gas and electricity savings of more than £200 per year giving a short payback time. With volume production the additional cost is expected to fall to £400 and even lower as the technology matures. However it is likely that the units will be sold through leasing arrangements which will make them more attractive to households without easy access to capital to replace failed boilers. The leasing system may also be a vehicle for the introduction of energy service contracts with households.

4.3. The projections of installed capacity by 2020 correspond to capturing a quarter, a third and a half of the boiler replacement market as shown in the graph below. Note that the ultimate potential for micro-CHP is much greater than the 2020 projections, of the order of 30-50GW.

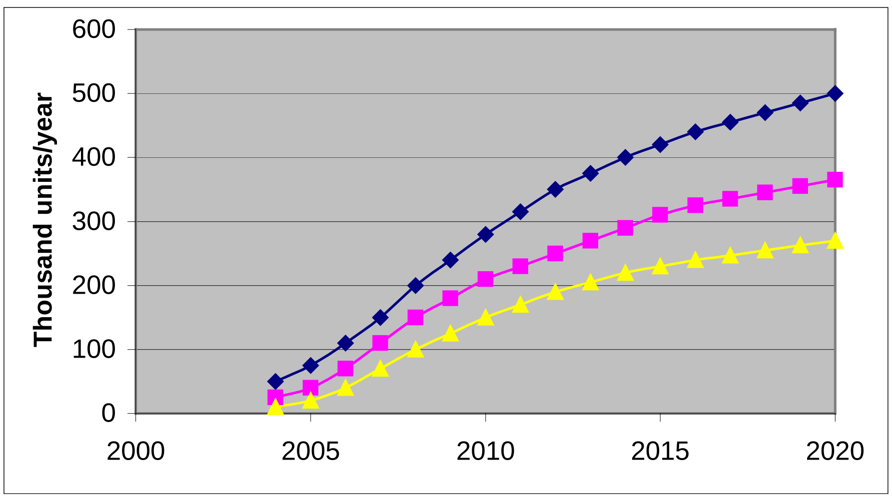

Figure A2.1 Projected growth rates in micro-CHP units

4.4. The Ekins projection of total CHP capacity includes 1.9GW(e) of micro-CHP, which it notes is a conservative estimate. The average electrical output of micro-CHP units has been taken as 1.5kW(e). The smaller units have outputs between 0.9 and 1.1kW and there are larger units with an output of 3kW(e).

5. The following table summarises the various estimates of CHP capacity that are available.

Table A2.1. Estimates of CHP potential (GW(e)

		ETSU (2010)	Ekins (2020)	PIU (2020)
Conventional CHP		10.0 – 16.8	17.7	-
Micro-CHP	domestic	-	1.9	2.8 – 5.3
	commercial	-	-	0.5 – 1.0

[15] The BRE Domestic Energy fact File gives an overall efficiency for domestic central heating of 70%. When the electric component (at 100%) is removed the gas fired systems have an average efficiency of about 65%.

6. As well as overall capacity there are two other parameters of significance for the supply/demand balance; namely heat and electrical efficiencies and load factors. These latter parameters determine the fuel burnt and annual productions of heat and electricity from a given capacity.
   6.1. The average efficiency and load factors reflect a wide range of plant. Much new plant is CCGT. The average for installed CCGT plant is an overall efficiency of 75.3%, an electrical efficiency of 25.1% and a system load factor of 60%. These are the values used for the average plant in 2020, by which time the best plant will have significantly better performance.
   6.2. It is possible that by 2020 fuel cell technology may have been sufficiently developed to provide CHP systems over a wide range of scales with significantly higher electrical and overall efficiencies. Such technology would also impact the domestic and SME markets significantly. However for the purpose of this projection we have **not** included any fuel cell technology.
7. The projections being made here are based upon the Foresight scenarios. These will differ in their willingness and ability to adopt CHP. These differences and the factors determining them are summarised below with estimates of the corresponding CHP capacities in 2020.
   7.1. **Business as Usual.** Although not a Foresight scenario it has been included in the current work for comparison purposes. Energy Paper 68 specifies[16] a CHP capacity of 7.6 GW(e) by 2010. This is close to the Ekins model which forecasts 6.6GW(e) by 2010 and 8.6GW(e) by 2020. Although there is a government target to achieve 10GW(e) by 2010 it seems unlikely to be achieved without additional policy measures. This projection has used the EP68 figure of 7.6GW(e) in 2010 and 9.6GW(e) in 2020. The contribution from micro-CHP is set at the low end of the range (2.8GW(e) domestic and 0.5GW(e) commercial).
   7.2. **World Markets.** It is unlikely that there will be any explicit policy incentives to increase the conventional CHP capacity above the BAU level. However increased liberalisation and trade is expected to improve the market penetration of micro-CHP units to the high case, on grounds of achieving maximum cost reductions. Thus the micro-CHP contributions are expected to be 5.3GW(e) in the domestic market and 1GW(e) in the commercial market.
   7.3. **Provincial Enterprise.** In this scenario there is an emphasis on achieving security of supply from local sources, but there is also less economic growth and less capital available than in WM.. The balance between these is expected to result in a conventional CHP contribution the same as applying under BAU conditions. There is also less emphasis on liberalisation and trade, likely to have an adverse effect on micro-CHP. The contribution here is limited to half of the lower end of the projections; 1.4GW(e) domestic plus 0.25GW(e) commercial.
   7.4. **Global Sustainability.** This scenario has strong values supporting sustainability in the context of liberalisation and trade. It also has strong economic growth providing high levels of innovation and capital availability. This scenario is therefore assumed to make use of the maximum CHP potential in all sectors. This corresponds to 17.7GW(e) conventional and a total of 6.3GW(e) micro-CHP.

[16] In para 4.22

7.5. **Local Stewardship.** This is the lowest growth scenario but has the strongest emphasis on sustainability and self-sufficiency. Under these conditions the adoption of CHP will be widespread, but constrained by capital and low economic growth (including stock turnover). It is therefore assumed to have intermediate levels of both conventional (13.5 GW(e)) and micro-CHP (4.6GW(e)).

8. The resulting generation of heat and electricity by the different CHP systems are set out below for each of the scenarios. Note that the micro-CHP figures for the domestic sector have been extracted from a detailed modelling of the UK housing stock that includes different age bands, levels of insulation and heating systems.

Table A2. 2. Summary of CHP by scenario

	2000	**BAU**	**WM**	**PE**	**GS**	**LS**
Capacity						
conventional	4.6	9.6	9.6	9.6	17.7	13.5
micro-domestic	0.0	2.8	5.3	1.4	5.3	3.9
micro-commercial	0.0	0.5	1.0	0.2	1.0	0.7
Total capacity (GW)	***4.6***	***12.9***	***15.9***	***11.2***	***24.0***	***18.1***
Electricity generated						
conventional	23	50	50	50	93	71
micro-domestic	0	12	18	6	15	12
micro-commercial	0	2	3	1	3	2
Total (TWh)	***23***	***64***	***71***	***57***	***112***	***85***
Heat generated						
conventional	61	101	101	101	186	142
micro-domestic	0	61	89	32	77	58
micro-commercial	0	8	15	3	15	11
Total (TWh)	***61***	***170***	***205***	***135***	***278***	***211***
Gas used						
Conventional	119	201	201	201	371	283
micro-domestic	0	82	119	42	103	78
micro-commercial	0	10	20	4	20	14
Total (TWh)	***119***	***293***	***340***	***247***	***494***	***375***

9. The above figures are those used in establishing the supply/demand balance for the different scenarios.