Maintenance of United Kingdom Electricity Supplies

to the year 2020 and Proposals for a

Secure Energy Strategy to 2050

A paper from PROSYMA RESEARCH LTD[1]

in response to the National Grid Consultation paper on "Operating the Electricity Transmission Networks in 2020" dated June 2009

by

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CONTENTS

SYNOPSIS

This report presents a response to the National Grid Consultation Paper "Operating the Electricity Transmission Networks in 2020" released in June 2009.

Following this synopsis, the Main paper sets out our approach in Section 1 (Introduction). Section 2 analyses the National Grid's "Gone Green" (GG) [1, 2] and the Government's Renewable Energy Strategy (RES) [3] scenarios in terms of capital and running costs. Section 3 analyses the risks in the "Gone Green" scenario. Section 4 presents our alternative "Secure Energy Strategy" (SES). This sets out the advantages in terms of security of energy supply, costs and CO_2 emissions reduction, of planning for and implementing a much greater proportion of nuclear energy in a greatly enlarged production of electricity by 2050.

Background

In its most recent paper, the Department of Energy and Climate Change (DECC) sets out its Renewable Energy Strategy (RES) [D], which aims at a further 15% reduction by 2020 in the 2008 emission levels in the economy and proposes that electricity generation's contribution to this reduction should be to increase the proportion of electricity derived from "low carbon" sources to 40%. "Low carbon" includes "renewables", nuclear power and "clean" coal, although this latter source is not defined. Nuclear and renewables currently make up about 20% of peak demand (60 GW).

In its Climate Change Act 2008 (CCA), the Government has laid down a target of an 80% reduction from the UK's 1990 level (770 million tonnes[4]) by 2050, i.e. to 154 million tonnes.

Notice that the targets apply to the whole UK energy economy, of which the electricity sector is currently only about 17% by end-user demand and 33% by primary energy demand.

It is clear, but often forgotten, that a direct consequence of the 80% (or even 50%) reduction target is that there must be a huge increase in overall low or zero carbon electricity production to replace most of the fossil fuel demand in the non-electricity sector to something like present-day Canadian levels per capita[5]. Our Secure Energy Strategy (SES) in Section 4 sets out a practical programme for achieving this.

Besides the increase in electricity generation, there must come a major expansion of the National Grid network to deliver this to the user. Because of the numbers involved, it is essential that to minimise capital costs incurred by the National Grid, new generating capacity must be as close as possible to the major centres of Britain's population[6].

The present government has further announced that it will enforce the EU Large Combustion Plant Directive (LCPD) which will have the effect of taking out of commission by 2015 8.3 GW of coal-fired power stations (or about 14% of Britain's peak winter demand of 60 GW), and an as yet unknown number of industrial coal and oil-based boilers, which also will not be able to meet the LCPD emission standards, the so-called "opted out" plant. At

[4] This is mainly CO_2 but covers CO_2 equivalent methane and other smaller gaseous contributions.
[5] At around 6,400 kWh per capita, Britain has the lowest consumption of electricity of our principal European and North American competitors, e.g. France 7,900, Germany 6,900, Switzerland 8,400 USA 12,200, Canada 18,000 [Ref 52].
[6] Most of which lie south of the Humber.

current rates of usage of the 20,000 hours of permitted run time from January 2008, 75% or 6 GW of opted-out electricity stations will have closed by 2012 [Ref S1]. To this loss of capacity should be added the closure of 6 of the 9 operating nuclear stations between now (August 2009) and 2018, totalling 6.7 GW, followed by another 2.5 GW in 2023, due to the same reason, i.e. their having reached the end of their already extended lifetimes.

British Energy, now 80% owned by Electricité de France (EDF), plans to commission at least one, possibly two, new nuclear stations on existing nuclear sites by 2020, totalling 3.2 GW of replacement capacity. In addition, planning permission has recently been granted for around 3 GW of new gas-fired capacity.

Taken together, the nation faces on current actual plans at best a net *reduction* by 2020 of around 11.5 GW in electricity generating capacity, or about 20% of the current 60 GW peak winter demand. Unless corrected, this gap will result in blackouts of this proportion during peak winter demand times. The Government's Energy Strategy [3] proposes to fill this gap by a combination of a six-fold increase in wind turbine capacity, unspecified other renewables, and further closures of some of the 10 GW coal generating capacity remaining after the LCPD 2015 closures in order to help meet the 2020 15% target. Because of its low average load factor[7] of around 25% in the United Kingdom, wind turbines' quoted GW outputs have to be down-rated by around 70% to compare with the 80-90% load factors of the coal, gas, oil and nuclear powered stations.

Implication of National Grid "Gone Green" Scenario

The National Grid has made a valiant attempt to apply the Government's 2020 15% emissions reduction target to electricity generation in its "Gone Green" (GG) scenario, by setting a target of 36% of electricity to come from renewables. It may be noted that the 2020 target of 40% in the GES for electricity from "low carbon" source is a bit easier to achieve, because 3.7 GW of the remaining present-day nuclear can be included, along with a possible 3.2 GW from the British Energy new build. The GG scenario however envisages 32 GW of installed wind capacity, which translates to an average power of about 9.0 GW (rather than the 10.9 optimistically assumed by the scenario). This gives an annual output of 78 TWh (rather than 98 TWh assumed in "Gone Green").

At an average maximum rating of 2.5 MW per wind turbine (l.5 MW for the existing 2,537 wind turbines) this would require at least 11,000 new-build windmills, of which nearly half are envisaged to be offshore. This would require a construction rate of 19 new wind turbines every *week* for the next 11 years, a rate we regard as impossible to achieve.

Interpreting the Government's Energy Strategy (GES), "Gone Green" additionally envisages 49 TWh[8] to be generated by "other renewables", principally biomass (18 TWh), hydro (6 TWh,) tidal and wave (6 TWh), to give a scenario "renewables" total of 147 TWh, or 36% of the 408 TWh electricity demand GG envisages for 2020 (present is 360 TWh).

As with the 98 TWh from the 2020 new-build wind target, we believe that a total of 49 TWh from "other renewables" to be unrealistic: if the whole UK sugar beet acreage were turned over to fuel, it would amount at most to a gross energy output of about 5 TWh, from which substantial process energy costs have to be deducted. Imported wood chippings for instance would still emit CO_2 on the same scale as other hydrocarbon sources. Possible

[7] Total annual output in TWh ÷ (maximum rating in GW x 8760 hours per year).
[8] TWh: 1000 GWh or a million MWh

hydro-electric sites in the UK have been exhaustively researched for decades with no result beyond the present 13 TWh annual production. The longest of the proposed Severn Barrages (Weston Super Mare to the Cardiff area) would only deliver power ranging from zero to 8.6 GW during the day, with an average of 2.5 GW or 22 TWh annually, at an optimistic capital cost of £21 billion, i.e. around 3 times the £0.20 per kWh of a new nuclear station. It should also be noted that 147 TWh is less than half of the UK 15% total renewables energy target of 330 TWh. There is no likelihood that local commercial or domestic initiatives, such as solar panels or Combined Heat and Power (CHP), can contribute more than a tiny fraction to the remaining 183 TWh, which corresponds to the output of 14 Areva[9]-sized nuclear reactors.

Even "Gone Green's" wind target of 98 TWh will be out of reach in our view, not only because the assumed availability of 34% is unrealistically high[10], but also because offshore installation and maintenance costs will make them up to 4 times as costly as nuclear power, even without fossil fuel backup (see below) and which, on the scale envisaged, would cripple British industry and impoverish the domestic consumer.

Realities of using wind-power for more than marginal electricity supply

Besides its cost and low availability, wind-power in the UK is particularly difficult to use on the huge scale envisaged in the CCA, the Renewables Energy Strategy paper and "Gone Green" because of (a) its distance from the centres of population and (b) its short-term (hour to hour) intermittency as carefully analysed in "Gone Green".

With few exceptions, existing power stations are within 50 miles of major population centres. 60% of the British population live south of the Humber, while the bulk of the installed wind-farms are 100-400 miles north of this. If existing line losses are as little as 2% per 100 km and this distribution of wind power were replicated in the new build envisaged, this would imply line average losses of around 8% for wind-generated electricity, still further reducing its contribution to end-user supply.

Moreover the cabling required to connect hundreds of wind farms to consumers up to 400 miles away on land (£1 million per mile) and, as mooted, 50 miles offshore (where cables can carry a maximum of 0.5 GW), is likely to cost at least £10 billion, which is greater than the whole book value of the Grid's existing network and will also disfigure huge areas of outstanding natural beauty. Should these extensions not be used, owing to a change of Government policy in the direction of a Secure Energy Strategy (Section 4), the Grid will be faced with demands to dismantle these cables and pylons and see a massive impairment of its balance sheet from which a future Government would be unlikely to rescue them[11].

The National Grid has one of the most sophisticated systems in the world for matching supply to demand at 230-240v and frequency to 50 Herz $\pm$ 0.5. It can probably cope with the sudden loss of a 0.5 GW generator to keep within this frequency range. "Gone Green" devotes much analysis to the effects of intermittency in 32 GW of nominal wind capacity. January 2009 had five days with 90% of the 4 GW of installed wind idle. The authors of this paper believe that it is vain to hope that the system can cope with a loss of more than 10% of the nominal 32 GW, however accurate the forecasts are, without calling up new build backup

[9] Proposed reactor for the EDF British Energy sites.
[10] Actual operating data from the 25,000 turbines in Germany and Denmark gives about 25%. The UK's 2,750 give about 20%.
[11] As happened with the former Railtrack.

fossil fuel stations at short notice. Germany with around 19,000 wind turbines has not closed a single fossil fuelled station for this very reason.

Using the wind variability data provided by "Gone Green", it appears that something like 10 GW of fossil fuel backup capacity for the nominal 32 GW of wind capacity would be needed for up to a quarter of the time, almost doubling the capital cost of the wind capacity. This would take the capital cost of offshore wind farms to an insupportable £10M per average delivered MW, compared with around £0.7M for gas and £1.6M for nuclear.

The Government's RES [3] provides for 3 pilot plants for so-called carbon capture and storage (CCS) where carbon dioxide would be stripped out of the steam and nitrogen exhaust gases from coal, oil and gas combustion. Section 3.3.9 (CO_2 storage requirements) shows that on any scale to significantly affect Britain's ability to reach its stated emissions targets, CCS is completely impracticable.

The Secure Energy Strategy (SES) alternative

The proposals to give effect to the Government's Energy Strategy by building at least 11,000 2.5 MW wind turbines over the next 11 years (without fossil fuel backup) at a capital cost of around £30 billion, plus £8-10 billion for grid extensions, plus unspecified other renewables at anything up to £10M per average delivered MW, together with the closures of existing plant, will lead to blackouts in the period up to 2020 and beyond and if actually implemented, would represent in our view the largest misallocation (around £80 billion) of resources in our entire history. Because of its size and because electricity is vital in every part of our national, commercial and domestic life, these proposals clearly pose a threat to the nation's very survival as a modern first world power.

We therefore propose an alternative strategy, the Secure Energy Strategy (SES) focussed on securing our energy supplies both up to 2020 and beyond to 2050. We believe that Britain must move off its present 92% energy dependence on fossil fuels for national security reasons, not specifically for CO_2 reduction reasons[12], but because over the next 15-20 years output from our North Sea oil and gas reserves will fall to near zero from its peak 2004 output of around 220 Mtoes (million tonnes of oil equivalent) equal to about 92% of 2004 UK energy consumption[13] (about 2,500 TWh as heat energy). Given the possible renewables' outputs and costs (discussed above and in Sections 2.3, 3.2 and 3.3), the bulk of the replacement of this vast amount, even after user efficiency gains of say 30%, can only be supplied by nuclear power, for which we set a 2050 target of 750 TWh or 100 GW capacity on about 20 sites. This should be built over the next 32 years following the first new reactor in 2018 (see Fig 6 and 6A) mainly around the coasts of Southern Britain using all the existing nuclear sites[14] with their connections to the Grid, at an average distance of 50 miles from where most of the population actually live.

While large, this capacity is only 15 GW more than France has built over the same length of time (around 2.6 GW per year) and which it is currently adding to. In our view this should be seen as the most vital national programme we can ever embark on, requiring a national

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[12] Britain's total emissions of around 650 million tonnes of CO_2 represent 2% of the world's, and are less than 3 years of the new-build Chinese coal emissions.
[13] Up to 2004 (the peak production year) North Sea oil and gas yielded a small surplus of about 2 Mtoes over our national consumption, now (2009) it yields a growing deficit as production falls.
[14] New sites will be necessary of course with up to 5 GW per site.

effort of will and commitment. To help finance this programme, we propose that nuclear electricity should be included in the renewables obligation certificate scheme and that a new British-owned Nuclear Corporation be established with mainly state capital at first, diverted from the £80Bn which will be wasted otherwise on the Government's Renewables Energy Strategy, to work in parallel with the French and German power companies who have expressed serious interest in building nuclear stations.

Because of its present low electricity consumption by comparison with other countries' (footnote 5), the UK peak winter to low summer demand variation is abnormally high. This has been seen by some as setting a barrier to the deployment of nuclear stations. But this has to change as transport, industry and commerce become increasingly electrified with tariff incentives to encourage overnight car battery charging on a major scale, and industry and commerce adjust their demands to new tariffs.

Need for Legislative Change

While this nuclear programme (with some retained fossil fuel sources for peak load provision) will deliver both energy security and ultimately, CO_2 emissions reduction of some 300 million tonnes (or 45% of present) (see Section 4, Figs 10 and 11) the country will need to retain all its existing fossil fuel capacity, and add some additional largely supercritical coal fired capacity through the period to about 2035 until sufficient new nuclears are on stream. It will thus be necessary for the UK to disregard the EU Large Combustion Plant Directive and the CCA 2020 target of 15% renewables, on the grounds, if they need to be stated, of overwhelming national need. Along with the 2020 15% "renewables" target, the CCA gives the 2050 80% emissions reduction target the force of law. Revising these to no particular target in 2020 and to say 50% in 2050 (the original EU target incidentally) will require parliamentary approval, unless the present restrictive grounds for revision are relaxed, given the dire need set out above. National Grid itself will need of course to judge how much the Government's renewables strategy will be changed in the light of the realities which have been set out in this paper. Any such change in the direction of a much greater nuclear programme (Figs 6 and 6A) will have of course major implications for the Grid extension and renewables programme.

1. Introduction

1.1 Many informed bankers and economists foresaw the great banking crash of 2008 but felt powerless to avert it, perhaps because no-none wanted to hear or because it flew in the face of the established consensus. Similarly many engineers can see that our country is heading for a massive energy crisis in the coming decades, but find their Cassandra cries elicit little response from Government and business. The purpose of this paper is to place, in the public domain, an analysis of the risks identified in the National Gird consultation paper of June 2009. Risk mitigation strategies are identified and an alternative Secure Energy Strategy is presented. While electricity generation is central to the functioning of a modern society, in the United Kingdom it is only 17% of final user demand. Our SES (Section 4) is a strategy for the whole energy economy, in which electricity will grow to about 50% of final user demand.

1.2 With the demise of the former electricity generating boards and the fragmentation of the generating companies, National Grid plc has become the inheritor of the greater part of electricity supply planning and coordination expertise in the United Kingdom. Thus, even though it is now a publicly quoted company, National Grid has a national and, to an extent, a legal duty to advise the government of the day on both practical and strategic issues in this field. This paper is aimed at assisting with this process.

1.3 Our approach was, in the first instance, to compare the projected mix of generation capacity outlined by National Grid in Gone Green [1] and in detail in the National Grid consultation paper Operating the Electricity Transmission Networks in 2020 [2] with that suggested in the Department of Energy and Climate Change (DECC) UK Renewable Energy Strategy Paper (RES) [3]. We have analysed the practicability, capital costs and running costs imposed by the necessity to accommodate in "Gone Green" the wind turbine programme and emissions reduction objectives in the RES.

1.4 In this analysis we have cross-referenced answers to the specific questions raised by National Grid in their consultation paper (page 28).

1.5 Finally, based on the risks to our people exposed by the analysis of the GG and RES scenarios, we present an alternative "Secure Energy Strategy" (SES) with a particular emphasis on the greatly expanded role which electricity generation and distribution must play in the commercial and domestic life of our nation in future.

1.6 We regard the issues raised by the National Grid Consultation Paper as fundamental to the future of our country. Too often, the media, and the BBC in particular, address the issue of electricity supply as solely one of the price of domestic fuel to the consumer. In fact, without a reliable electricity supply grid, the very fabric of the society would soon fall apart. Food in storage would rapidly deteriorate, the distribution of essential supplies would be disrupted and water supply and sewage treatment works would cease to function. Without a dependable and economic supply of electricity, our industries would become uneconomic and either cease to exist or migrate overseas.

2. Projected Electrical Generation Mix with and Assessment of, Feasibility, Capital Cost and Generating Costs

2.1 Comparison of National Grid and DECC Scenarios

2.1.1 Table 1 shows a comparison between the electricity generating capacities envisaged. National Grid's "Gone Green" for 2020 Scenario [1] and consultation paper [2] are compared with the capacities given in or derived from the DECC Renewable Energy Strategy Paper [3].

Table 1: Assumed Generating Capacity

Generating Source	Current		Nat. Grid 2020 "Gone Green"		DECC 2020	
Gas	27.5 GW	36%	34.5 GW	35%	? GW	? %
Coal	28.4 GW	37%	19.8 GW	20%	? GW	? %
Nuclear	10.4 GW	14%	6.9 GW	7%	? GW	? %
Onshore Wind	1.6 GW	2%	10.5 GW	10%	14.5 GW	14.5%
Offshore Wind	0.8 GW	1%	18.5 GW	19%	13.0 GW	13%
Hydro	1.0 GW	1%	1.1 GW	1%	2 GW	2%
Bio-energy & other renewables	1.5 GW	2%	3.3 GW	3%	4.5 GW	4.5%
Other, inc Oil & Cross Channel Link	5.3 GW	7%	5.5 GW	6%	? GW	? %
Total	76.5 GW	100%	99 GW	100%	100 GW (?)	100%
Pump Storage	2.7 GW		2.7 GW		2.7 GW (?)	

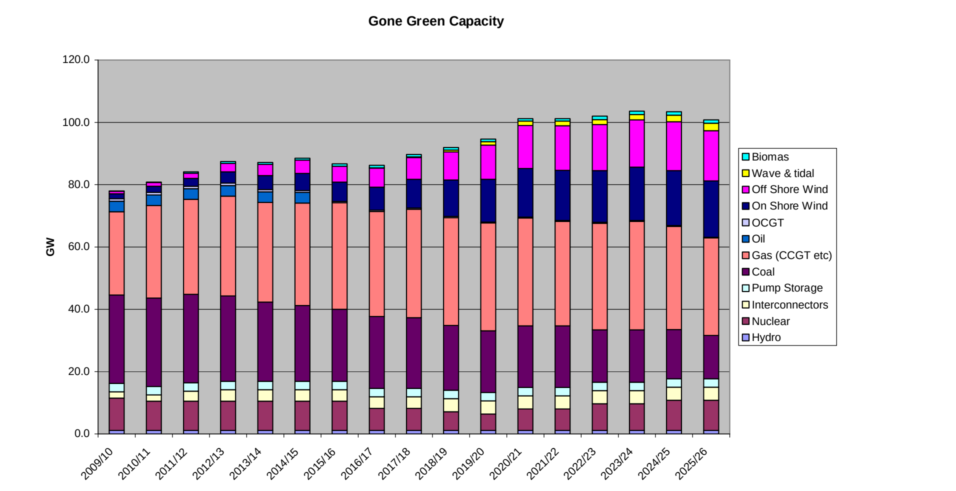
2.1.2 The main differences between the National Grid and such figures as are given by DECC, concern the shift from offshore to onshore wind generation and rather more optimistic assumptions by DECC on Biofuel energy, which DECC assumes will more than double to 4.5 GW and wave or tidal generation which DECC suppose may increase from close to nothing to 1 GW, which is nearly the rated output of a Pressurised Water Reactor. It should be noted that the Wind, Wave and Tide maximum rated GW outputs quoted in Table 1 must be down-rated by about 70% to account for their intermittency.

2.1.3 The recent shift in planning from offshore to onshore wind generation capacity against the trend assumed by DECC may be a reflection of recent doubts about the capital and running costs of offshore wind power. An example of this is that Shell has pulled out of the London Array Wind farm, and the consequent need for a £1Bn loan from the European Investment Bank [8][15].

2.1.4 The DECC Strategy paper is deficient in meaningful estimates for generating capacity. Consequently the baseline for our assessment of feasibility, cost and risk will be the National Grid assumptions, but with the changed ratios of onshore and offshore wind projected by DECC.

2.1.5 The mix of capacity envisaged in the "Gone Green" scenario is shown in Figure 1, below. The dip in total capacity from 2015 to 2018 reflects the proposed reduction of coal fired plant required by the Large Combustion Plant Directive.

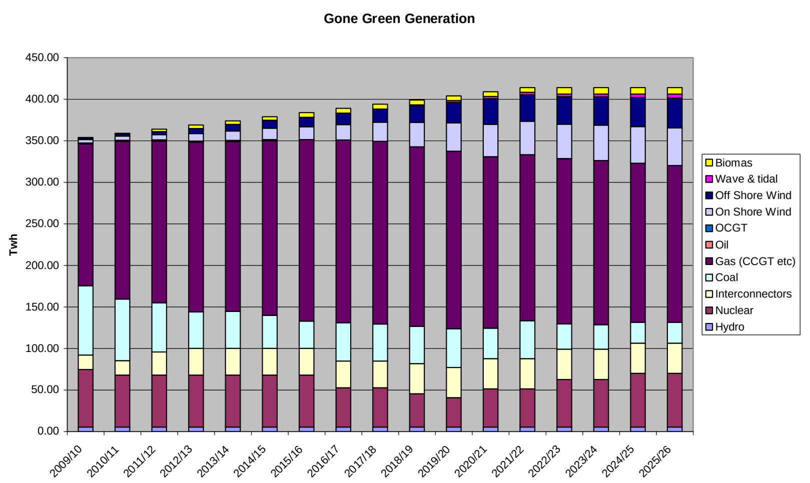
Figure 1: Nominal Generating Capacity envisaged for the "Gone Green" Scenario



2.1.6 The actual achieved generation mix would be significantly different from the nominal capacity mix in Figure 1, because actual wind capacity is only about 30% of its nominal capacity, owing to its intermittency. We have taken the current annual requirement for electrical power generation to be 354 TWh, which is expected to rise under GG to about 408 TWh in 2025/26. We have estimated the likely generation for each generator type to the year 2025/26 given in Figure 2 below. It is evident that natural gas continues to be the major source, particularly after the loss of much of the coal fired capacity from 2015. To minimise CO_2 emissions, renewable and nuclear energy are assumed higher in the National Grid supplier merit order than gas which is higher than coal when demand is significantly less than capacity.

[15] In response to this the Government has increased the subsidies for offshore wind by 33%.

Figure 2: Total Generation by Type for the "Gone Green" Scenario



2.2 Capital Costs and Feasibility of new electricity generating plant

2.2.1 The capital costs of power generation plant are significant not only to indicate funding requirements and payback periods but also because these figures give a good indication of both manufacturing and construction timescales and financial risk. However, the figure of price per maximum rated kW of installed power is not particularly meaningful since some power plant will produce electricity at virtually full power for most of the year with, perhaps, a two week annual shutdown period whereas other plant, particularly renewables, tend to produce intermittent power which is significantly below the maximum power. Hence the maximum (rated) power for each source is adjusted by the assessed load factor and availability factor to give an effective capital cost per average delivered kW.

2.2.2 The load factor for wind turbines is taken as 30%, the figure assumed in the National Grid Consultation Paper [2]. For tidal power, barrage or immersed turbine, a load factor of 25% has been assumed. For gas and coal fired sources, which are normally arranged to provide variable load, a load factor of 90% has been assumed and for nuclear power plant, assumed to provide the base load, a load factor of 95% is assumed.

2.2.3 The availability factor for each source is taken to be the figure given by National Grid in Table 6 [2] but, in the case of new nuclear plant, which has extended periods of shutdown for maintenance and refuelling during the summer months, an availability of 77.5% is assumed by taking the mean of the summer availability and the winter availability given in National Grid's Table 8 [2]. For the proposed Severn Barrage, an availability of 100% is assumed.

2.2.4 The nominal capital cost figures and those adjusted by both load factor and availability for average delivered power, are given for in Table 2.

Table 2: Comparison of Nominal and Effective Capital costs		
Generating Source	Nominal Capital Cost. £/kW	Capital Cost for average delivered power, £/kW
CCGT	500 [9]	600
New Build Coal **	1,000 [10]	1,200
Onshore Wind	800 [11]	2,800
Offshore Wind	2,700 [8]	10,500
Severn Barrage	2,400 [7]	9,700
Submerged Tidal turbines	2,500*	8,000
New Nuclear Power	1,600 [5] [14]	2,200

* Estimated capital cost similar to offshore wind
** Excludes the cost of carbon capture and storage

2.2.4 The feasibility of achieving the DECC renewables strategy [3] may be assessed by estimating the investment per year, over the next eleven years, to achieve the projected programme. This is dominated by the cost of the onshore and offshore wind farm programmes.

2.2.5 DECC envisages an increase of onshore wind maximum rated capacity of 13 GW. Applying the figures given in Table 2, above, this would require a total investment of £10.4Bn or nearly £1Bn per year which is possible in financial terms, but only if investors can see a worthwhile return on capital. The programme also assumes that at least 6,000 wind turbines, or an average of 1.5 turbines for every day, can be installed which may be difficult, particularly if, as seem likely, there is significant local opposition. The equivalent figures for the National Grid baseline programme are £700M per year and just over one wind turbine per day.

2.2.6 DECC also envisages an increase in offshore wind maximum rated capacity of 12 GW. This would require a total investment of £32Bn or nearly £3Bn per year to erect and install an average of more than 1 turbine every day. This seems most improbable to us, particularly if there is to be a simultaneous onshore programme, as this, at less than a third of the capital cost, would be potentially more financially rewarding or, at least, less financially unrewarding.

2.2.7 The DECC strategy also assumes that, by 2020 some 25 TWh annually could be generated from biofuels and that this could be produced by about 12 million tons of wood. This seem improbable to us on two counts. Firstly figures given elsewhere in the DECC report assume a 45% thermal efficiency of generating plant and secondly it is unclear how this wood or other biofuel could be obtained. If all UK sugar-beet production were turned over to biofuels, it would produce less than 5 TWh. The National Grid baseline programme is slightly less unrealistic in this regard, assuming around 60% of these figures.

2.3 Capital and Running Cost of Extended Grid

2.3.1 Even at constant electricity generated, the Electricity Grid will require massive extensions to accommodate the increased supply from renewables, principally wind turbines. Previously, power stations have been constructed reasonably close to the principal areas of demand. Wind turbines, however, must be placed where they can best harness the wind and such places are frequently in the more remote parts of the country. Additional power lines and conversion stations will be required to connect these into the grid at a significant capital cost. There will also be increased transmission loss associated with the greater transmission distances and these may be considered as a running cost.

2.3.2 The approximate mileage of the additional electricity grid has been estimated for Table 3 and these estimates used to provide approximate calculations of both capital cost and transmission loss cost. The capital cost of new gridlines is assumed to be £1M per mile except in the case of the two North South interconnectors which are assumed to be twice that. The transmission cost has been assumed to be 2% per 100 miles, assuming an average grid utilisation of 25% for wind and a cost of power at 5p per kW.

Table 3: Capital and Running Costs of Extended Grid				
Additional Grid Lines	Distance, including spurs	Max capacity	Capital Cost	Transmission loss
From - to	(miles)	(GW)	(£M)	(£M/year)
South West - Cardiff/Bristol	150	2	150	6
South Wales - Cardiff/Bristol	75	1	75	1.5
Mid Wales - West Midlands	100	2	100	4
North Wales - North West	125	2	125	5
East Anglia - SE England	100	1	100	2
East Anglia - Et Midlands	75	1	75	1.5
Yorks & Humberside - E Midlands	75	1	75	1.5
Cumbria - North West	150	2	150	6
Northumberland - Newcastle	75	2	75	3
S W Scotland – Central Belt	125	2	125	5
S E Scotland - Central Belt	75	2	75	3
N E Scotland - Central Belt	300	4	300	24
N W Scotland - Central Belt	250	4	250	20
Eastern North – South Interconnect	400	10	800	80
Western North – South Interconnect	400	10	800	80
	2,475		3,275	242.5

2.3.3 The additional investment in the electricity supply grid to support wind power, including some extra adjustments to the current grid, is thus likely to be in the region of £4Bn; of this perhaps £2Bn would be required in Scotland. These investments, would have to be made early on in the wind power expansion programme in order to make use of the additional turbines as they are commissioned so, almost all the investment would need to be made in the first 5 years at a rate nearly £1Bn per year.

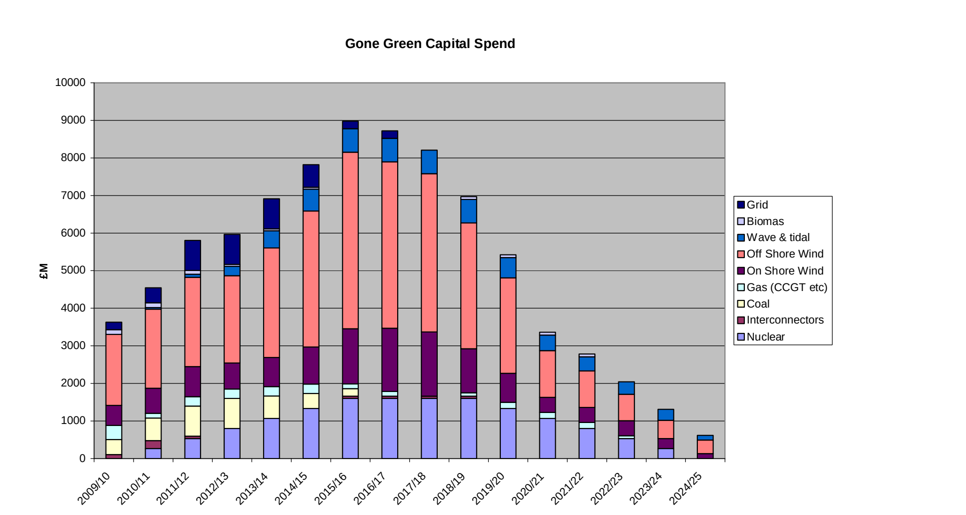
2.3.4 The total electricity generation cost per year in the UK is around £11Bn-£12Bn, so the additional transmission loss has the effect of increasing this by some 2% to which must be added the requirement for increased return on capital and a virtual doubling of the maintenance costs. It is believed that this additional requirement for generation capacity (around 0.5 GW) was omitted from the calculations in the National Grid Consultation Paper [2] and the additional cost to the consumer was omitted from the DECC Renewable Strategy Paper [3].

2.4 Total Capital Cost of "Gone Green"

2.4.1 The cost of the proposed DECC renewable strategy, as interpreted by National Grid in "Gone Green" were calculated using the capital costs given in Table 2 for the programme given in Appendix B of the National Grid Consultation Paper [2]; the National Grid projection stops in the year 2025/26 by which time some £85Bn will have been spent on new construction plant, two thirds on renewables, to which should be added the £4Bn previously noted for greatly extending the national electricity grid network.

2.4.3 A graphical representation of the required expenditure, including the costs of extending the grid, but excluding any cost attributable to carbon capture and storage, is given in Figure 2 below. These figures assume, unrealistically, that no further generating plant or associated grid modifications are required after 2025.

Figure 3: Capital Expenditure for "Gone Green" Scenario



2.5 Total generating costs of different technologies

2.5.1 The generation costs for each power technology depend upon both the amortisation of the capital costs and the running costs including operating staff, maintenance and fuel. The fuel costs are most significant for CCGT and coal fired plant, much less so for nuclear plant and less even for renewables if the need for standby power is disregarded.

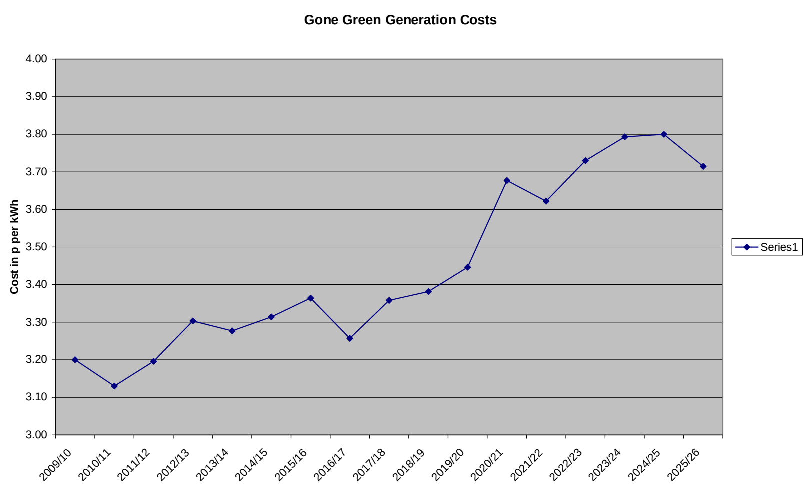
2.5.2 The total cost of electricity generated by the various technologies is given in Table 4. These figures are based on the Royal Academy of Engineering's 2004 commissioned report [4] uprated in the light of construction and fuel increases since then.

Table 4: Cost of Generating Electricity (p/kWh)		
	2004	**2010**
CCGT	2.20	3.0
Coal	2.50	3.4
Onshore wind	3.50	4.7
Offshore wind	5.30	8.0
Nuclear	2.3	3.2
Tidal	6.6	8.9

Note: The cost of standby generation is exclude in all cases as is the cost of CO2 capture and "carbon trading"

2.5.3 Based on the foregoing assumption, we estimated the average generation cost for the GG mix of generator types to the year 2025, to be as given in Figure 4 below.

Figure 4: Cost of Generation in p per kWh for the "Gone Green" Scenario



3. Risk inherent in the "Gone Green" Scenario

3.1 The objectives of a National Energy Strategy

3.1.1 It seems to the authors that a national electrical energy policy should have four main objectives:

(1) minimise the risk of future energy shortages

(2) assure a continuous and reliable supply of electrical energy for both domestic and commercial consumers

(3) replace the almost total (92%) reliance on fossil fuels, which are inherently polluting and, in future will not be under our control, by a new major energy resource under our control

(4) ensure that costs, both to domestic and commercial users, are as low as practicable and in line with the costs in other competing economies

There is a high degree of overlap between these aims but it is clear that any national energy strategy should be assessed against a balance of all four.

3.1.2 Renewables of all types, which are at the very core of the Government's Energy Strategy, clearly will not, on the scale envisaged, meet any of these objectives adequately.

3.1.3 If the National Grid "Gone Green" scenario, which is in close harmony with current government policy, is not capable of adequately meeting all four of these key objectives, it will ultimately be to the obvious detriment of National Grid plc, its shareholders and the nation as a whole. Consequently we tested the "Gone Green" scenario against the need to provide continuous electricity, at a competitive cost and reduced emissions.

3.2 The Risk to Continuous Supply

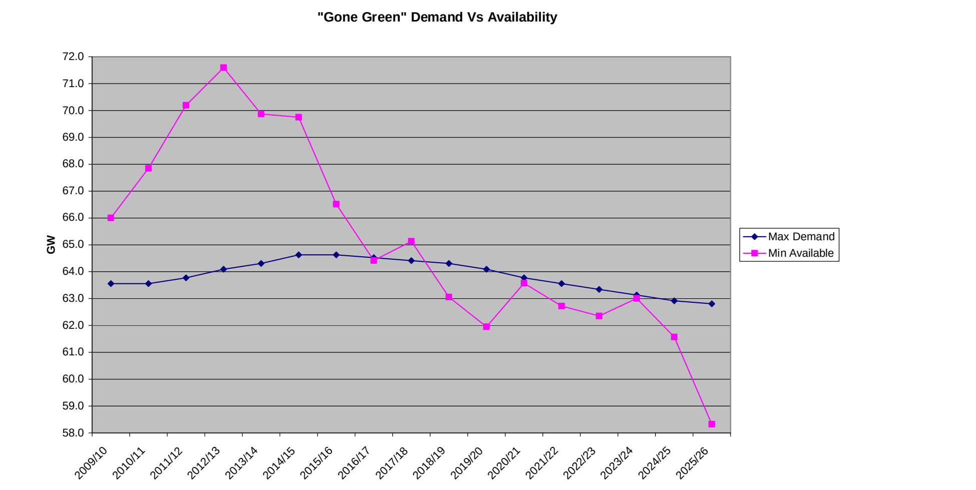
3.2.2 The National Grid requires a Short Term Operating Reserve (STORR) to ensure that electricity supplies are maintained, without interruption, over the complete island of Great Britain. This Reserve varies according to the time of year but, at times of peak winter demand, is presently about 4 GW on top of a maximum demand of nearly 60 GW or about a 7% margin.

3.2.2 Currently the generating capacity provided by wind turbines is hardly significant but, if the wind generation capacity increases to the extent envisaged in GG, this will increase to around 9 GW by the year 2025. At that time the maximum generating capacity from wind turbines, wave and tidal generation envisaged in "Gone Green" is 36.5 GW out of a total generated of just over a 100 GW. Taking account of projected winter availability, these figures are reduced to a maximum rated capacity from wind, wave and tide of 30.5 GW out of a total UK capacity of 85 GW.

3.2.3 We do not believe that National Grid's Reserves approach is adequate to the task of dealing with the chance of virtually no electricity from the wind turbines on a certain number of days in the year. Figures given in the consultation paper [2] showed that the total load factor for all wind generation in the UK fell to only 6% at a time of peak demand on 5 January 2009; two days later, this fell to only about 1% (i.e. 99% not functioning), although fortunately not during peak demand. These assessments are confirmed by a recent separate assessment by Poyry [15] which confirmed that, for Britain, there are likely to be occasions, possibly lasting up to 3 days during the period of winter peak demand, where the total output from wing turbines may fall to below 5% of maximum rated capacity.

3.2.4 We consider that a safe operating margin would be obtained by adding an additional margin of 95% for all available power provided by wind, waves and tidal generation to the current STORR of 7%. Using this principle, we calculated the maximum winter demand and the minimum available power for the years to 2025. These results are given in Figure 5 and it can be seen that there is a significant danger of power cuts from 2016, a near certainty of power shortages from 2018 and a catastrophic shortage from 2024.

Figure 5: Max Requirement Vs Minimum Supply for "Gone Green"



3.3 Feasibility of the "Gone Green" Build Programme

3.3.1 An assessment has been made of both the capital and generating costs in the preceding sections; the implications of these costs are now further considered.

3.3.2 As can be seem from Figure 3, the "Gone Green" Scenario requires a massive investment in wind power, both onshore and offshore and a not insignificant investment in coal fired plant to replace the power stations closed as a consequence of the EU Large Combustion Plant Directive.

3.3.3 The onshore wind programme requires approximately 1 GW of new plant to be erected every year for the next five years, rising to 2 GW from about 2015. This is roughly 500 wind turbines per year rising to 1,000 at a cost of nearly £1Bn rising to more than £1.5Bn per year. According to the British Wind Energy Association website, 530 MW maximum rating of onshore wind farm construction was completed in 2008 and a further 2,226 MW maximum rating was approved (approximately 60% of that requested). However, the rate of submissions slowed in 2008 to only 1,772 GW of which only about 30% were for construction in England where 85% of the UK population lives. Nevertheless, the onshore programme seems as though it might, just, be achievable provided the factories producing wind turbines can keep place with increasing world demand (with the impending closure of the Vestas factory on the Isle of Wight, none of these will now be in the UK) and provided that local opposition, very strong in some of the more heavily populated parts of England, can be overcome.

3.3.5 The offshore programme seems very much more problematical. The DECC programme requires an immediate build rate of about 0.5 GW per year, rising to 1 GW in 2012 and then 2 GW from 2017. (All these are maximum ratings: average ratings are about 30% of these figures.) The construction costs of offshore wind energy are around three times higher than on shore so the required investment is £2Bn per year rapidly rising to 4.5Bn with an installation rate of around 2 turbines per day. The current capacity is somewhat less than 1 GW with a further 1.25 GW under construction and 3.75 GW approved. Because of the very high construction costs, in excess of £2.5Bn per maximum GW, or £8Bn per average GW, even with the renewable obligation subsidy the economics look very dubious. EDF withdrew recently from the previously approved Cromer offshore wind farm whilst Shell has withdrawn from the London Array consortium, possibly for these reasons.

3.3.6 To use the power generated in wind farms, both onshore and offshore, it will be necessary to modify and extend the nation's electricity grid which, over the last 50 years has evolved to distribute power from a relatively small number of large generating units located close to the areas of greatest demand. The total investment required is probably in the region of £8Bn to £10Bn and the rate of investment is up to £2Bn a year for 5 years, starting years before the investment can be fully used. This is a massive investment even for a company the size of National Grid, whose total market capitalisation is about £14Bn of which about £7Bn is represented by the UK Grid.

3.3.7 Will investors or lenders be found to provide the required funds? How will National Grid achieve an economic return on its investment, given that this extended grid is likely to be lightly loaded most of the time and that the power lost in transmission will be relatively high, perhaps as much as 10% of that generated? What will be the implications for National Grid if the projected increase in wind energy does not occur, either for reasons of engineering and economic practicality and/or if some future government, seeing that the current Renewables Energy Strategy is failing (for reasons described elsewhere in this report) withdraws it support, perhaps by reducing the value of the Renewables Obligation Certificate to allow its extension to nuclear power?

3.3.8 The fundamental purpose of wind power and other renewables such as tidal and wave power, is to reduce the need to burn fossil fuel, but when the wind and waves do not function as desired, back-up power is required, sometimes at a very high level. Consequently a substantial reserve of fossil fuel generation is required. Currently there is an adequate reserve of gas and coal fired plant to provide this but, with the impending closure of supply of some 11 GW of coal-fired electricity plant in 2015/16 plus an unknown number of industrial plants, new fossil fuel plant will be required to be constructed to replace this. The "Gone Green" scenario supposes that some 4 GW to 5 GW will be coal fired, including the projected 1.6 GW Kingsnorth Power station.

3.3.8 The final government approval for Kingsnorth and other new supercritical coal fired generating plant is understood to depend upon verification that it will be built in such a way that Carbon Capture and Storage (CCS) can be retrofitted when this technology become commercially available.

3.3.9 The authors have considered this and believe that there are serious issues concerning the feasibility of CCS on the required scale. For example, the projected Kingsnorth capacity would generate about 8.5 million tonnes of CO_2 per year. In a liquid state, this would occupy a volume of about 7.5 million cubic metres per year. To maintain this huge volume in the liquid state will require a pressure of 60 bar at 22 ^oC, 50 bar at 15 ^oC, 40 bar at 6 ^oC. A one metre diameter pipe provides 785 m^3 per kilometre, so Kingsnorth's annual output of CO_2 would fill around 10,000 km of pipe, 4 times round Great Britain. 50 bar will require a pipe wall thickness of at least 10 mm of mild steel or around 250 tonnes per km or 2.5 million tonnes per annum. These vast numbers, which cannot be circumvented by even more fantastical ideas of inserting liquid CO_2 into the sedimentary rock from which the oil came, should be enough to halt any investment of scarce resources into CCS. But if not, the huge cost both financial and energy of separating 8.5 million tonnes of CO_2 per year in the Kingsnorth case from around 27 million tonnes of nitrogen and about 1.4 million tonnes of steam in the exhaust gases, probably by absorption in ethanolamine (and this is just for one 1.6 GW power station) should prevent the CCS fantasy from going any further. The GG scenario in fact envisages total new coal plant construction with CCS of approximately 5 GW.

3.3.10 Additional gas fired Combined Cycle Gas Turbine (CCGT) plant could be built instead of the supercritical coal plant, but this would rather defeat the object of having secure and diversified energy supplies although CCGT plant generates only about 48% of the CO_2 from supercritical coal for given electrical output.

4. Plan for the Secure Energy Strategy

4.1 Objectives

4.1.1 We have put together an alternative "Secure Energy Strategy". The prime objectives are to ensure reliable, continuous and long-term economic supplies of electrical energy, to enhance the long-term security of our national raw energy fuels and, in the period from 2025 to 2050, to reduce very substantially the emissions of CO_2 into the atmosphere.

4.1.2 From the analysis of wind power, tidal barrages, biofuels, coal and gas, only nuclear can provide a non-carbon, reliable, long-term energy source meeting the prime objectives above.

4.1.3 The Secure Energy Strategy (SES) for the period 2010-2050 should therefore be developed with nuclear power planning and construction at its core, but taking advantage of renewable sources where they can add value. Some fossil fuel generators will be required to provide transient peak load. As the nuclear capacity becomes steadily available, the electrification of road transport and new building will provide the requisite demand flattening.

4.2 Outline Plan

4.2.1 This SES plan envisages a greatly expanded nuclear programme for which the first new reactor comes into service in 2018, the second in 2020 and thereafter at the rate of 1 or 2 per year, replacing and supplementing the existing nuclear stations until the total nuclear power plant capacity reaches 50 GW in 2035 and 100 GW in 2050. At this point, nuclear power would provide approximately 80% of the total average electrical power generated in the UK and about 50% of total energy demand in the UK.

4.2.2 In the SES scenario, from the mid 2030s nuclear reactors will continue to be built until a capacity of 100 GW is built by 2050. About 10 GW coal fired capacity and a similar amount fired by natural gas will remain. The rest will be provided by renewables, while pumped storage, the cross Channel link and improved start-up and shut-down techniques for the fleet of new nuclear stations will manage major demand variations.

4.2.3 To ensure that there is not a shortage of power between 2015 and 2025, a derogation from the Large Combustion Plant Directive would be necessary and also new supercritical build coal plant of a further 10 GW would be required to be undertaken up to the year 2020; this is approximately twice that envisaged in the “Gone Green” scenario. Wind power, both on and off shore, would not be subsidised more than nuclear beyond the capacity currently approved, namely about 6 GW maximum rated capacity by 2015.

4.3 Capacity and Capital Cost

4.3.1 The mix of capacities to the year 2050 is shown in Figure 6 and 6A. Figures 6B and 6C show the mix of the generation technologies.

Figure 6: Total Capacity by Type for the “SES” Scenario to 2025

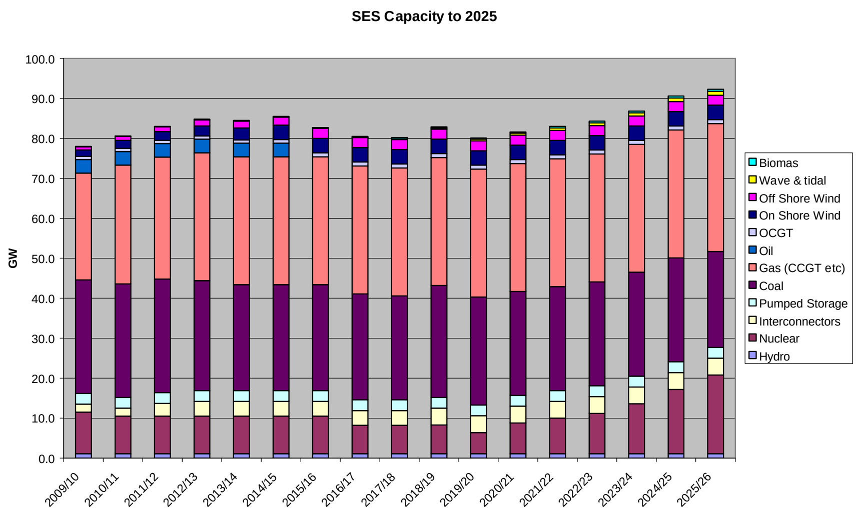


Figure 6A: Total Capacity by Type for the “SES” Scenario to 2050

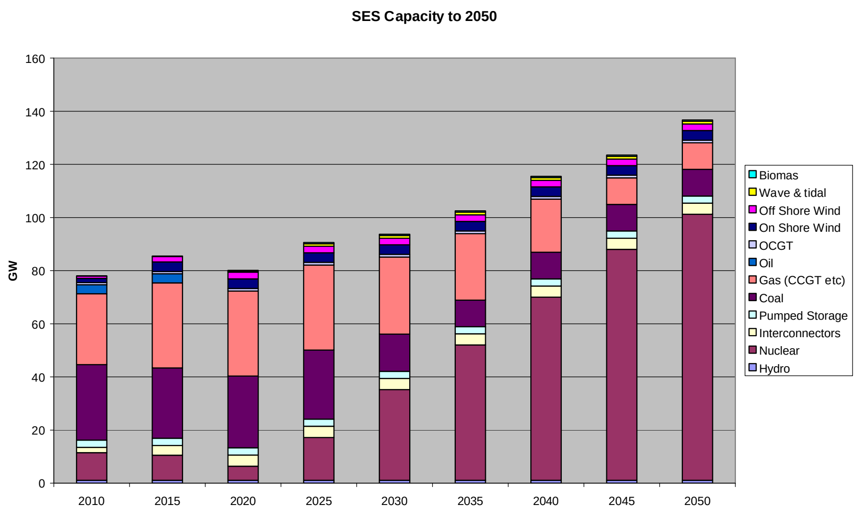


Figure 6C: Total Generation by Type for the "SES" Scenario to 2020

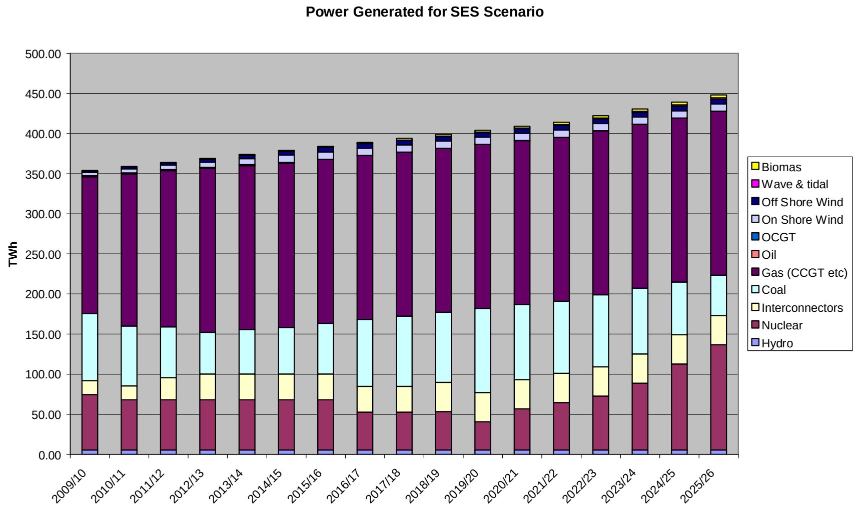
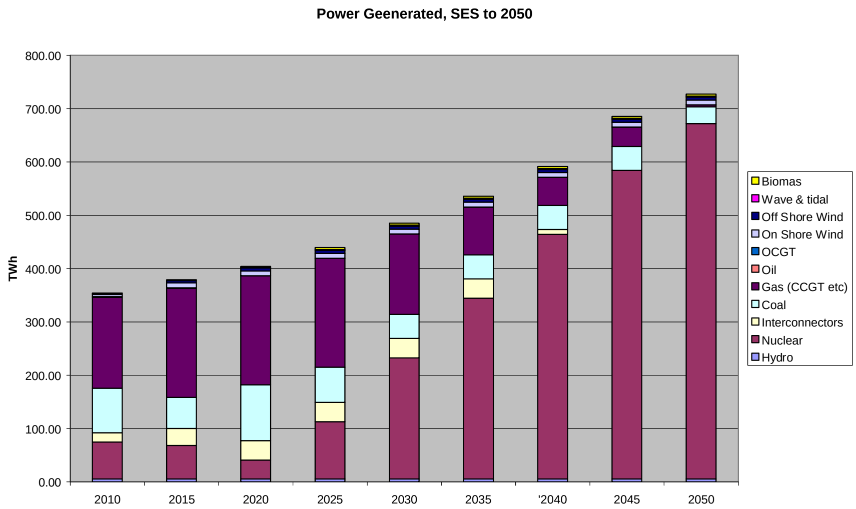


Figure 6D: Total Generation by Type for the "SES" Scenario to 2050



4.3.2 The total cost of this programme is estimated to be about £90Bn to the year 2035. The need to extend the grid would be minimal, perhaps a maximum of £1Bn so the total saving of capital expenditure, compared with the National Grid's "Gone Green" scenario, would be in the region of £10Bn to £15Bn and the spend profile significantly flatter and more affordable. The evolving capital cost can be seen in Figures 7 and 7A.

Figure 7: Capital Expenditure for "SES" Programme to 2025

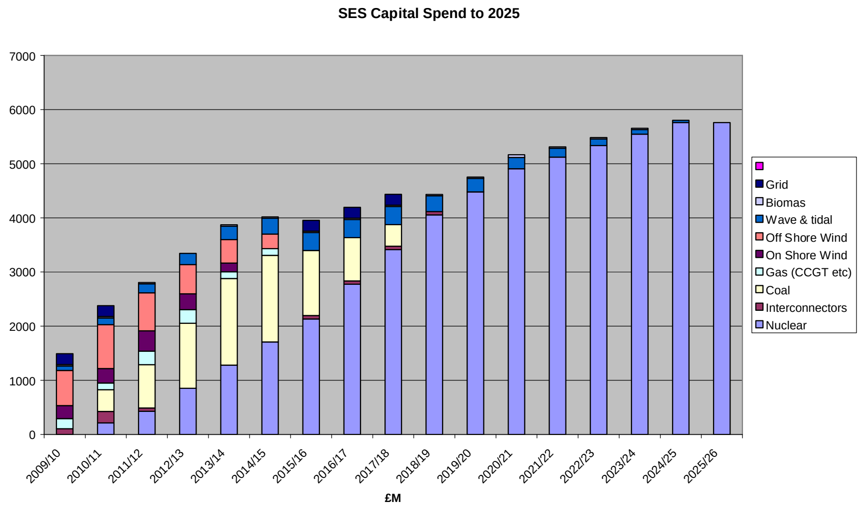
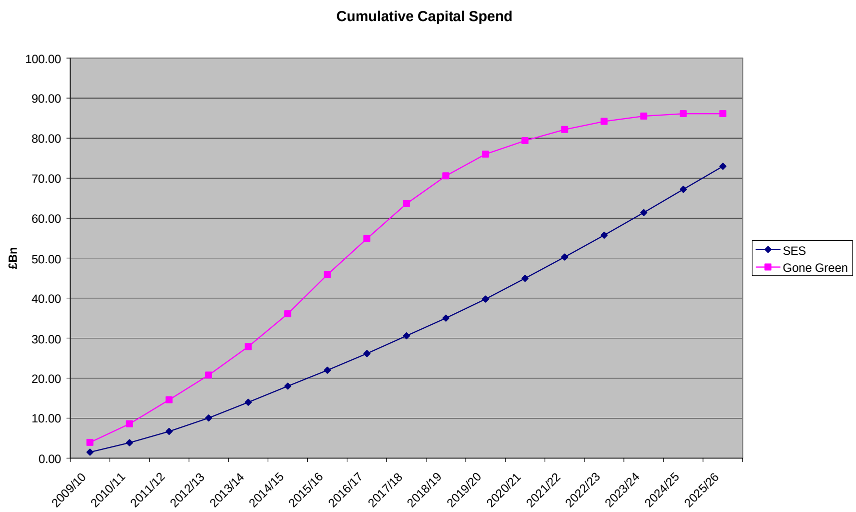


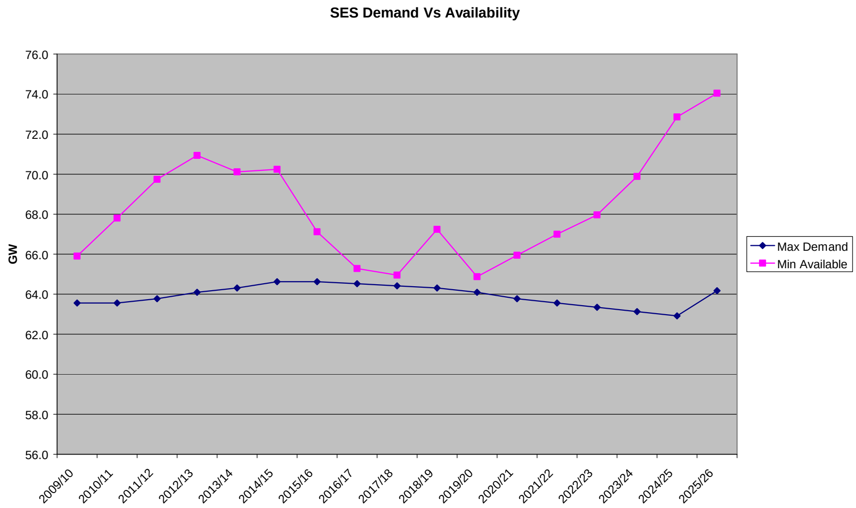
Figure 7A: Capital Expenditure Gone Green Vs "SES" to 2025



4.4 Energy Supply Risk and Generating Cost

4.4.1 The Secure Energy Strategy was tested for possible power supply interruptions during the winter peak under the same rules as the "Gone Green" Scenario with a 7% margin, plus an additional margin of 95% for available power provided by wind, waves and tidal generation. The results are shown in Figure 8.

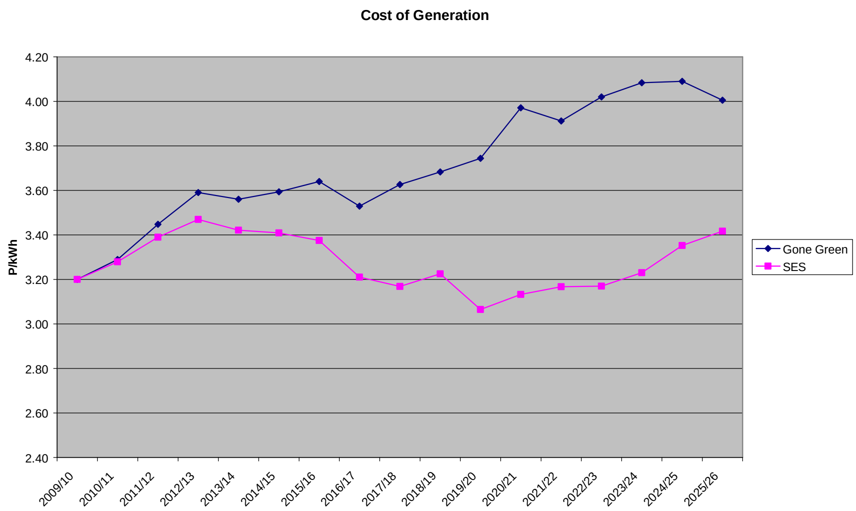
Figure 8: Maximum Requirement Vs Minimum Supply for SES



4.4.2 It is evident that, though the surplus of available capacity over demand is potentially tight around 2017 to 2020, there is always a positive margin; this could become critical if the nuclear build programme were delayed, so the necessity of retaining the older coal fired plant as an emergency reserve becomes apparent. The margin of available capacity over demand continues to increase after 2025 as additional nuclear plant joins the grid.

4.4.3 The cost of generation for the Secure Energy Scenario was tested against the the “Gone Green” Scenario and are compared in Figure 9.

Figure 9: Cost of Generation in p per kWh, SES Vs “Gone Green”



4.4.4 It is evident that, whereas in the “Gone Green” scenario the mean cost of generated electrical energy increases from the current price of approximately 3.2p per kWh to about 4p per kWh in 2025 (an increase of 25% or maybe around £2.5Bn per annum on the national electrical energy bill) under the Secure Energy Strategy the price is roughly constant. These figures exclude the additional transmission losses in the grid and the additional maintenance costs associated with the extended grid. If these are added, the cost of the national energy supply is likely to rise by a further 5%.

4.5 Carbon Dioxide Emissions

4.4.1 The Secure Energy Strategy was tested and compared with the "Gone Green" scenario for projected CO_2 emissions. To compare the two it was necessary to extend the "Gone Green" Scenario to 2035. For this comparison, it was assumed that offshore wind capacity, onshore wind capacity and wave/tidal capacity were each expanded by 0.5 GW per year from 2025 and biofuel energy by 0.2 GW year. For both scenarios, the total power generated was assumed to be flat at 410 TWh from the year 2020. The results are given for emissions per TWh for both the "Gone Green" and SES Scenarios to 2025 in figure 10 and for SES to 2050 in figure 11 respectively.

Figure 10: Total CO_2 Emissions Compared

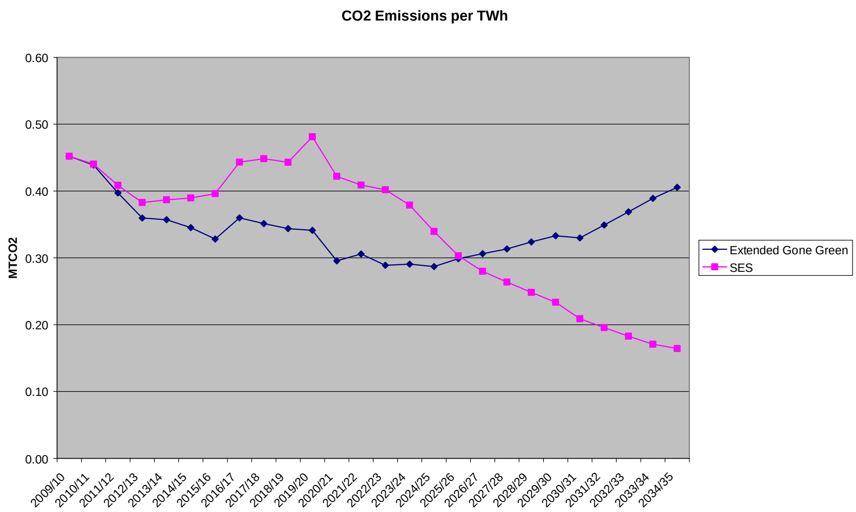
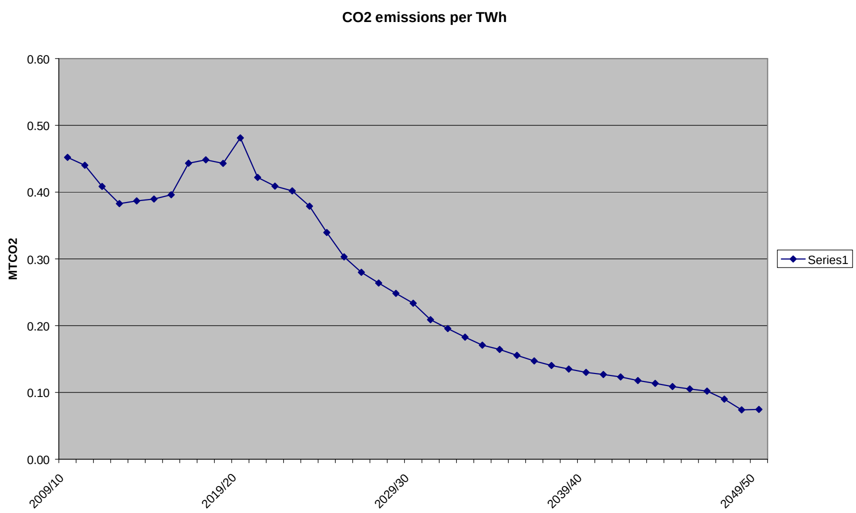


Figure 11: CO_2 Emissions per TWh to 2050 for SES Scenario



4.4,2 It can be seen in Figure 10 that for the Secure Energy Strategy, the total CO_2 emissions initially rise as we pull out of the recession and because we retain the coal fired generating plant that would otherwise be decommissioned by the year 2015. However, by the year 2030, the emissions for both scenarios have fallen to not much more than half the present levels. From 2030 to 2050 Figure 11 shows that the SES reduces the carbon emissions for TWh of electricity to about 16% of today's figure and (although not shown on Figure 11) to about 35% in the economy overall.

5. Conclusions

5.1 It has been established that the "Gone Green" Scenario will be difficult if not impossible to achieve. If it were achieved, it would pose significant risks to the nation's supply of electrical energy during the winter peak period of December to March and the cost of electrical generation would be likely to rise by some 25% by the year 2025 at constant prices.

5.2 The cost of extending and otherwise modifying the national electricity grid to implement the "Gone Green" Scenario will require National Grid plc to invest some £10Bn, mostly in the next 5 or 6 years. It is not clear how National Grid will secure a reasonable return on capital invested nor, if the "Gone Green" strategy cannot be achieved, or is severely modified by the government of the day, possibly for good practical reasons, how National Grid plc will recover any worthwhile cost on its massive investment and indeed, whether it could remain solvent under such circumstances.

5.3 The alternative Secure Energy Strategy indicates a route to safeguard Britain's electrical energy supply system and reduce the need for investment by at least £10Bn over the next 20 years. The much reduced investment required by National Grid plc would pose miminal risk. The price of electricity would remain almost level.

5.4 To implement the Secure Energy Strategy it will be necessary both to start a new civil nuclear programme in the next 12 months and to achieve derogation from the EU's Large Combustions Plant Directive.

6 National Grid Questions with short answers & refs to text

No	Question	Short answer	Reference to sections in text
1	How do National Grid's observations align with your experience or modelling of wind generation?	Optimistically	3.3
2	Are we correct in assuming that wind generation is controllable enough to assist in operating the networks?	No	3.2
3	Should National Grid assume that Supercritical Coal generators will provide some flexibility in operation which will assist in operating the networks?	Very little	3.2
4	Should we assume that Nuclear generators will continue to concentrate on base-load operation?	Not necessarily	4.2.2
5	Is it likely that Carbon Capture plant will impose material restrictions on the operation of electricity generating plant?	No – CCS will not happen	3.3.9
6	Are there other aspects of tidal or marine technologies that we should consider further at this stage?	No	-
7	Are there other restrictions we should consider in developing a view on gas fired generator flexibility?	No	-
8	What is your view of future electricity demand growth and how would you quantify any uncertainty around this?	Electric cars will constitute the biggest new demand	4.1.3
9	Are there other developments which will change the way that electricity will be consumed in 2020 that we should consider?	Increased use in new houses, offices and replacement equipment in industry	-
10	Do you share our view that distribution companies, suppliers, aggregators and ourselves will all value and compete for demand side services?	Possibly	-
11	Are our assumptions around the number of electric vehicles in 2020 reasonable?	Yes	-
12	Is it valid to assume that electric vehicle charging will be co-ordinated via a smart grid or something similar and will react to price signals?	Yes	-

No	Question	Short answer	Reference to sections in text
13	Do you foresee a greater or lesser role from embedded and distributed generation than we have assumed?	Overall, major extension of the network to 2025 required under "Gone Green"	2.3.1 3.3.6
14	Is our anticipated improvement in wind forecasting performance at 4 hours ahead achievable?	Possibly but not really relevant	3.2.3
15	Do you have any views on our projected Short Term Operating Reserve requirement under "Gone Green"?	Yes	3.2.4
16	Do you have any views on our projected volumes, prices and costs for STORR under "Gone Green"?	Yes	3.2.4
17	Is National Grid's current view that "low wind" events across Great Britain need to be considered when evaluating electricity operating margins reasonable?	Yes	3.2.4
18	Are our generator availability assumptions reasonable for application to analysis of future operating margins?	Wind is too high	Footnote 8
19	We would welcome comments from market participants on how they expect to manage periods of low wind generation output and whether this is an important consideration for them.	-	-
20	Are we correct to highlight the importance of wider European issues in electricity operating margin analysis?	No	-
21	Are there further technical solutions for maintaining operating margins which we have not mentioned here?	Yes, new techniques for shut-down/start-up of nuclear reactors	-
22	Do you think National Grid's view of future operating margins is useful and do you have views on how this should be presented?	See answers to Questions 15-17	-
23	Are our assumptions regarding the level of electricity demand during the minimum demand periods reasonable?	Definitely not in long-term to 2035	-
24	Are our generation availability assumptions for minimum demand periods reasonable?	Yes, up to 2020	-
25	Is our central assumption regarding wind generation bid prices related to ROCs reasonable?	Likely to change	-
26	Is it reasonable to assume that minimum demand periods will be managed using Interconnectors and Wind Generation in preference to the curtailment of Nuclear Generation?	No	-
27	Do you agree with National Grid's view of increased balancing activity in the future due to variation in market length?	Possibly	-
28	Do you agree with National Grid's view that ramping effects will impact on operation of the networks?	Yes	-

No	Question	Short answer	Reference to sections in text
29	Do you believe that a new approach is required in the development of System Operator to generation or demand control point interfaces for 2020?	If wind goes ahead, answer is yes	-
30	Are there any specific factors which suggest that adequate flexibility will not be available to National Grid for use in operating the networks in 2020?	Yes	Synopsis – Realities of wind-power
31	The combined challenge of: (a) ensuring the networks are operated safely and securely against a background of generation variability; whilst (b) getting more from existing infrastructure; suggests to us that control, communication and information systems have a greater part to play in controlling flows across the transmission networks. Are there alternative approaches which should be considered?	For GG you have to retain back-up fossil fuel	Synopsis – Realities of wind-power
32	What criteria should National Grid use in developing any requirements for information regarding embedded generators? Are there other ways of obtaining this information?	-	-
33	Are there additional options that National Grid should consider to maintain a Black Start capability?	-	-
34	Are we correct in assuming that new interconnectors will be able to meet some of our Balancing Services requirement?	Possibly	-
35	What is your view on the potential of electric vehicles to provide balancing and other energy services?	Fundamentally important	Synopsis & SES (Section 4)
36	How much of the electricity demand in Great Britain do you think could be regarded as discretionary or deferrable and hence available for use as a Balancing Service or other energy service?	Tiny if you stay with GG, larger if you adopt SES	-
37	What specific actions should National Grid take to facilitate Balancing Services from demand-side providers while maintaining the required quality and volume of service?	-	-
38	Are there further aspects of storage or other storage technologies we should consider when looking forward to 2020?	No	-
39	What are the prospects for the provision of Balancing Services from new OCGTs or other “Back-up” generation?	Small	-
40	Is our mapping of technology to Balancing Services reasonable?	-	-
41	Is a statement of National Grid’s view of its long term Balancing Services requirement useful to industry stakeholders?	Yes – but all depends on which generation strategy is adopted	-
42	What period should a long term Balancing Services Requirement statement cover?	5 years minimum	-

43	What changes to the current reserve products would better encourage the provision of reserve services?	-	-
44	What actions would ensure that procurement of reserve services does not impact adversely on the efficient operation of the wholesale energy markets?	-	-

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8 List of Tables

Page

List of Figures

Page