RENEWABLE ENERGY FOUNDATION

21 JOHN ADAM STREET, LONDON, WC2N 6JG

TEL: 020 7930 3636. FAX: 020 7930 3637

EMAIL: research@ref.org.uk

WEB: http://www.ref.org.uk

RENEWABLE ENERGY FOUNDATION RESPONSE TO:

DEPART OF ENERGY AND CLIMATE CHANGE:

28 OCTOBER 2009

The Renewable Energy Foundation is a registered research and education charity encouraging the development of renewable energy and energy conservation whilst emphasizing that such development must be governed by the fundamental principles of sustainability. REF is supported by private donation and has no political affiliation or corporate membership. In pursuit of its principal goals, REF highlights the need for an overall energy policy that is balanced, ecologically sensitive, and effective.

Mr Paul-Frederik Bach

Paul-Frederik Bach has more than 40 years' experience in power system planning. He worked with grid and generation planning at ELSAM, the coordinating office for west Danish power stations, until 1997. As planning director at Eltra, Transmission System Operator in West Denmark, he was in charge of West Denmark's affiliation to the Nordic spot market for electricity, Nord Pool, in 1999. Until retirement in 2005, his main responsibility was the integration of large amounts of wind power into the power grid in Denmark. He is still active as a consultant with an interest in safe and efficient integration of wind power, particularly the prevention of disturbances by advanced system control measures.

Dr John Constable

John Constable is the Director of Policy and Research for the Renewable Energy Foundation, an independent charity that provides data and information about renewable energy technologies. Dr Constable read English at Magdalene College, Cambridge, taking his PhD there in 1993. He subsequently taught at both Kyoto University, Japan, and at Cambridge, where in 2005 he was a Senior Research Fellow of Magdalene College. He is the co-discoverer, with the Japanese particle physicist and economist, Hideaki Aoyama, of the mathematical distinction between verse and prose in English. He has been working in energy policy since 2004, and he is currently responsible for co-ordinating the Foundation's large circle of practical and academic engineers, and for the direction of policy.

Professor Michael Laughton

Michael Laughton is Emeritus Professor of Electrical Engineering at the University of London. He has served as Specialist Advisor to parliamentary committees on alternative energy and energy efficiency and published on energy policy and electrical power systems. He is a member of the energy policy advisory committees of the Royal Academy of Engineering and the Royal Society.

Dr Lee Moroney

Lee Moroney is the Director of Planning for the Renewable Energy Foundation. She has a PhD in Chemistry from University College Cardiff. After gaining her PhD, she worked as a research scientist on synchrotron radiation studies of solids in the United Kingdom and the United States. In the 1980s she started a computer consultancy specialising in bespoke mathematical and database software for stock broking. She has 30 years of experience in data analysis and information mining from large datasets of varying quality in both scientific and financial disciplines.

The following document is a synthesis of the views and observations the four authors. The responsibility for the final form of the text is that of Renewable Energy Foundation, not its advisors Professor Laughton and Mr Bach, though we believe that this final form correctly reflects their views.

Q 1: How do you see the electricity system evolving between now and 2050? Are there other scenarios that could add to the evidence base?

The direction of evolution between now and 2050 will depend on drivers that can to some extent be influenced by the British Government, but it should be recognised that to a significant degree the trajectory in the shorter and medium term is already determined, and this may in some contingent situations limit Government's options.

REF has consistently indicated that the current renewables policy is in effect a gas policy, since the renewables encouraged contribute little firm capacity, thus leaving the need for firm plant barely diminished. Consequently investors in conventional plant are presented with an energy market that is reduced in size, and economically and physically volatile. In such a circumstance they have no option but to manage risk by selecting gas turbines, which are the least capital intensive option. Indeed, we think it unlikely, without major changes in policy, that private capital will support the construction of nuclear or coal with CCS.

A predominantly gas fired electricity system in 2020 is exposed to considerable uncertainty with regard to fuel availability and cost. If gas supply is very tight, and prices very high, it is conceivable that emergency measures to diversify the fuel mix could result in sudden changes in portfolio composition that are very hard to predict. These changes could have, in themselves, a dramatic impact on subsequent system evolution.

Bearing this mind, we find looking beyond 2020 imaginatively interesting, but it is unclear to us that much of any precise character can be determined. When planning a long journey study of the map would not enable even the most reflective driver to anticipate particular movements of the steering wheel, and of course road closures because of accidents cannot be anticipated.

However, generally, with such a long time horizon there is a good reason for considering more structural changes than anticipated in the consultation paper, and we would hope to see a stronger integration between electricity supply, heat supply and transport in order to maximize the efficient use of renewables, particularly wind energy, and reduce consumption of fossil fuel. Whether this will actually occur can only be guessed at, not least because the short term direct of travel seems to expose the United Kingdom to the over-concentration on gas and, thus, to the risk of distressed and disruptive policy correction on pragmatic grounds.

Indeed, we are somewhat concerned that the level of forward planning apparently intended by the Government is so precise as to render the resulting system fragile. Put another way it is a pre-requisite of a robust system or plan that it is sufficiently flexible to deal with events that are inherently unpredictable.

Q 2: How could smart grids contribute to efforts to decarbonise the UK's electricity generation mix while maintaining security of supply?

We presume that this question is directed largely to the consideration of employing smarter grids as a mechanism to cope with stochastic variability of renewable generation.

In this connection the consultation paper concentrates on the risk of electricity shortages, and the ability of flexible demand to shave peak demands. While this is understandable, we refer DECC to our remarks in our response to the National Grid consultation (Appendix 1) where we note (see paragraphs xvi and 15.7) that Danish experience, however, shows clearly that operating reserves must be provided for both upward and downward regulation. That is to say, an increasing penetration of wind power will cause an increasing surplus of electricity and consequent wind curtailment. Eventually additional wind power will be unprofitable. Provision of flexible demand to absorbing surplus electricity could thus make additional wind more reliable, and allow a higher share of intermittent generation such as wind power.

However, we observe that it should not be presumed that such additional demand is infinitely flexible and compliant with wind availability. That is to say that it is likely that if steps are taken to create additional demand, for example, the recharging of electric cars, then this demand become autonomous and persist even at times of low wind output, thus constituting additional load for the conventional sector.

Q 3: What are your views on the assessment of the outlook for spare electricity generation capacity and its implications for security of electricity supplies?

Historically in the development of national electricity supply industries, the planning process has sought to ensure that sufficient spare generation capacity is available in order to meet security of power supply over and above that needed to meet maximum load demand. This margin, the , accounts for the unavailability of installed capacity (for example due to maintenance and unexpected mechanical failure) and ensures that loss-of-load probabilities stay within the historic norms relevant to security of supply.

The present planning margin in the UK advocated by the system operator, National Grid, is now around 19% to 20% based on known conventional plant outage rates and the short construction times required by CCGT stations.

Power capacity credit of intermittent sources

Intermittent generation such as that from wind may or may not reduce the planning margin depending on the perception of the balance between the risk of consequences and the probability of lack of supply when needed. It is widely believed that that wind generation plant can contribute to the security of supply to a certain extent, though this extent is widely debated. Theoretical studies suggest that a reliable capacity credit factor can be determined by using known existing conventional plant reliability statistics combined with simulated wind turbine output based on measured meteorological office data.

This capacity credit factor is simply an indication of the amount of existing conventional baseload capacity that could be displaced for various levels of wind penetration without degrading the overall system reliability standards.

Results indicate that for low levels of penetration the firm power capacity displaced equals the mean power delivered by the wind generation, i.e. measured by the total wind generation average load factor, but decreases with increasing penetration of wind. This diminishing return in the value of wind capacity is because of the increasing importance of there being little output from all sources of wind generation.

For the GB system the total onshore wind capacity credit has been determined theoretically to a first approximation to be the square root of the GW of wind capacity installed with variations above and below this value depending on the geographical dispositions of wind plant.[1]

We note in passing that one of the authors of this response (PFB) has practical experience of wind in the system, and is from this perspective reluctant to assign any capacity credit to wind. However, he acknowledges that in a system several times larger than that of Denmark, a statistical approach may be reasonable. We are aware that National Grid has commissioned ongoing work from the University of Edinburgh (see), and have had sight of some non-confidential work related to these studies.[2] The calculations we have seen cover the range from 0 to 30 GW wind power on the top of existing capacity. 30 GW of wind power could generate between 70 and 100 TWh per year, and the corresponding energy penetration would be between 17% and 20%. We note that the traditional calculations employed may be usable in this range but in our view not much beyond 20%. The Edinburgh researchers are clearly well aware of the issues stimulated by their work, and the need for further data and methodological innovation.

We raise this matter here in order to observe that this issue is the focus of sophisticated academic analysis, and that DECC should not regard it as a settled field. In the meantime it is the view of Mr Bach that DECC should proceed cautiously with regard to assumptions about capacity credit.

Implications for conventional plant capacity needed

On any view, including the square root rule of thumb referred to above, the result, imposed for purposes of maintaining adequate response and reserve requirements, implies that a high degree

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[1] Michael Laughton, "Power supply security with intermittent sources- conventional plant capacity requirements", Platts , 460 (10 Oct. 2005), pp. 10-12.

[2] Chris Dent. Pers. Comm.

of conventional (dispatchable) plant capacity is retained in the system to support wind generation. Thus, for 25 GW of installed wind capacity only 5 GW of conventional plant can be replaced leaving 20 GW in the role of standby capacity (also known as "Spare" or "Shadow Capacity").[3]

A further confirming analysis can be derived from a report for the DTI by Ilex Consulting, (known as the SCAR report), concentrated on the additional costs associated with renewable generation taking into account also system security of supply using historic probability measures.[4] Taking data from tables in SCAR we can derive the following table:

Table 1: High electricity demand growth scenarios considered for the UK with various penetration levels of wind energy by 2020

Peak Demand MW	***Energy from Renewables***	***Installed wind capacity MW***	***Conventional capacity* required MW Margin***	***Other Renewable Capacity MW***	***Spare capacity MW***	***Spare Capacity Margin***
			89,500 = 18%		***15,400***	***20%***
			86,000 = 14%		***21,800***	***29%***

These results illustrate starkly the size of the problem when in basically an island electricity supply system such as in Great Britain, wind generated electrical energy replaces other energy from other generators, but not the need of other generator capacity. The conclusions can be summarised as follows.

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[3] "An engineering assessment of the Policy and Innovation Unit's Energy Review", submitted by The Royal Academy of Engineering (2002).

[4] ILEX Energy Consulting report to the DTI (Oct. 2002).

These conclusions place an especially onerous security of supply requirement on market driven investment.

Q 4: What are your views on the assessment of the operational challenges of managing the electricity system with a higher penetration of intermittent generation?

Danish Experience

For empirical evidence on this matter we refer DECC to our recent study of the Danish and German electricity spot markets and wind power flows: Paul-Frederik Bach, (REF: London, 2009), a copy of which has already been provided to the Department (further copies are available on request).

For other perspectives we believe that our response to National Grid's consultation, which forms Appendix 1 of this document, is also relevant.

Generally, we conclude that the analysis, as summarised in 3.39 is somewhat over-relaxed. DECC writes:

> *The updated analysis leads the Government to the conclusion that, at this stage, the risks to electricity security of supply over the next decade are manageable to 2020, but that the outlook may be less benign beyond 2020.*

Our reasons for suspecting that difficulties may become apparent before 2020 include but are not limited to the following:

- Our study of the Danish case shows that far from having absorbed 20% of MWhs from wind power, the much larger and interconnected system of Germany-and-Denmark has absorbed approximately 7% wind energy, and this only because of the fortunate availability of Norwegian hydro and suitable interconnection. The UK is, thus, much closer to the frontier of knowledge than has been previously suspected.
- While much assistance is expected from interconnection, and REF fully supports this development, it is necessary to be realistic as to what can be expected from such links. Our study of the Danish case confirms the view that interconnectors are not in themselves balancing solutions, but only portals through which such services can be obtained, at a price.
- Our assessment of the retirement rate of existing flexible plant (oil, coal, and gas) under the Large Combustion Plant Directive (LCPD) is less optimistic than DECC's own view. Opted-out plant are currently using up their allocation of remaining running hours vey quickly, and if derogations for these generators are not forthcoming it seems to us that there might well be difficulties in supporting the levels of intermittent generation well before 2020.

- The curtailment of wind output is a viable means of managing some aspects of intermittency, but it is economically disadvantageous to the generator if uncompensated, and extremely costly to the consumer if compensated since the lost generation is heavily supported by the Renewables Obligation.
- As is made clear in our response to National Grid, we have reasons to think that the timing of wind generation may have been mismodelled through a failure to take correct account of wind shear. We remark at 1.9 in that document: "From our preliminary analysis, it appears that one third of the total wind energy is generated between the night hours of 23:00 to 07:00, which if repeated across the country, could have significant implications for balancing at times of low demand and high wind power penetration."

Portfolio Generators and Reserve Provision

From the viewpoint of generators the increase in variability in the supply/demand ratio arising from an increase of renewable generators in the supply mix has different significance depending on whether the plant is part of a portfolio (or a vertically integrated company), or is the property of a single asset company. Owners of a portfolio comprising a range of different plant are able to optimise the reliability, efficiency and flexibility of their generation fleet by combining their different units. Portfolio generators can:

- Afford to hold capacity in reserve as insurance against an outage since one unit represents a less significant proportion of their revenue than that of a single asset generator;
- Use the portfolio to follow demand without the need to aggressively two shift, as a single asset owner may be required to;
- Optimise generation around the units of the fleet to ensure that they gain maximum efficiency not only on a unit by unit basis but also between the spark spreads on different fuels.

In other words, the lack of capacity payments means that portfolio generators alone will find it practical to support significant reserve capacity during daily system operation. Aside from issues relating to free market access for new entrants in to this sector, it must be a matter for some concern that the provision of reserve capacity is left in the hands of a few companies only, companies that may find their resources fully deployed on other projects.

Q 5: What are your views on the assessment of the challenges for investment during the transition to a low carbon electricity generation mix, specifically for investors in low carbon electricity generation, and in flexible electricity generation?

Electricity may be a commodity but it demonstrates unique attributes when compared to other commodities. Indeed, one might say that it is effectively two commodities. Firstly, it is the provision of energy, the value of which should be apparent from the marginal costs of that energy.

Secondly, it is the provision of a capacity to produce that energy, whose value should be apparent from the cost at any time of marginal production capacity. Peak demands for virtually all other commodities can be catered for by storage, but in the case of electricity it is necessary for the market design to provide a sufficient capacity to meet all uncertain peak demand under all circumstances.

The market as it is currently structured does not reward the provision of capacity. If investments in new capacity of whatever type of plant are to occur, there must be an expectation of suitable financial returns in the future from sales of **energy**.

In other words, any new conventional plant capacity (MW) needed for reasons of security and reliability of supply, including new nuclear, will have to be justified to investors by the expectation of revenue arising from the sales of energy output (MWhs). This is paradoxical, and perhaps places too a great a burden on the market. Indeed, as one commentator has put it:

> *In the oligopolistic situation that prevails in the UK electricity supply industry with only six large vertically integrated players supplying over 70% of the demand […] why should they have an interest in contributing to the supply margin (i.e. the spare generating capacity over and above that required to supply the country's winter maximum demand)?*

In other words, where there is no capacity mechanism producing commercial incentives for generators to invest in the necessary spare capacity they will not do so. Under such circumstances and faced with the serious consequences of an unreliable power system there is every reason to consider the establishment of a national strategic reserve of spare generation capacity, regardless of market economics, to be operated by the National Grid as necessary. Details of funding, ownership and rules of operation would need much further thought as suggested in para 5.8 of the Consultation Paper.

Q 6: What are your views on the problems that smart demand could address?

There are a number of problems with assessing the potential usefulness of smart demand. Firstly, there, as is noted in the IHS Global Insight report, there is insufficient information on existing demand patterns and the potential for time-shifting these demands. This information deficit needs to be rectified. However, given that UK electricity has not been conventionally used for heating (or cooling) the current potential for substantial gains is small. We suspect that some of the load identified by the IHS Global Insight report as being available for time-shifting might be potentially saved if we assume conservation practises will be adopted as a first priority.

We appreciate that the path to decarbonisation is projected to involve a switch to increased use of electricity for heating and transport. This would result in an increase in the potential electricity

[5] 'Electricity prices must rise to pay for new generating capacity', PB Power (July 2007).

load that may be time-shifted. However, the projected increase in wind power will increase the volatility in the time-of-day pattern of electricity production, perhaps invalidating assumptions as how to shift demand. Furthermore, substantial increases in **embedded** wind generation and other uncontrollable generation are also projected. This type of generation will be invisible to the System Operator, except as negative load, and may substantially increase the apparent volatility of customer demand. In view of this there are manifold difficulties in anticipating both the potential for smart demand and the problems it is required to mitigate.

In our opinion, it is at least conceivable that smart demand can only be relied upon to make relatively minor shifts in daily demand patterns. For example, a commuter will have the expectation that an electric car can be charged overnight on every night of the week, and the potential for time-shifting such charging will consequently be limited.

The consultation paper describes itself as "focusing on the use of smart demand for addressing system security issues" (4.13). Since employing smart demand for this remedial function may have negative impacts on and it would, perhaps, be more sensible to ensure that other alternative courses of action, problem avoidance for example, are selected first.

We do not doubt that flexible demand can contribute to a more efficient operation of the energy system, particularly if heat supply is included. But a major obstacle will be, understandable, reluctance among consumers if they feel that demand flexibility causes a reduced level of service. Therefore smart demand measures need to be accompanied by a package of building improvements, more efficient appliances and intelligent energy control to ensure that consumers are enthusiastic collaborators. This may be a problematic undertaking.

Q 7: What are your views on the estimates of potential smart demand among the different consumer groups, and the approach used to reach these estimates? What other approaches or estimates might be helpful?

More detailed information on demand must be gathered before robust conclusions can be drawn. We note that paragraph 4.20 says that "In GB no detailed half hourly information on demand is currently available…" Furthermore, the spread of the IHS Global estimates of existing discretionary load is wide and we are not aware of any firm estimates of projected discretionary load should electric cars and electric heating become widespread. We believe that resources should be set aside to gather this information.

Secondly, an intelligent demand must be able to respond to price signals in both directions. The potential from residential and commercial consumers can be mobilized gradually but would need to be in line with the installation of smart meters and intelligent appliances. The behaviour of households will probably change slowly.

Q 8: What are your views on the smart demand measures set out? In particular, for each of the measures, the Government are interested in your views on:

- **Whether and how they should be explored further**
- **Their usefulness for maintaining a balanced system in different timescales**
- **Their appropriateness for different customer groups**

REF is not convinced that the admittedly limited evidence shows that the smart demand measures are likely to be of significant use. We feel the measures are traditional, the potential usefulness will be limited and the development will be slow and expensive. The current consumption patterns are not well understood and the consumption patterns are predicted to change substantially if there is a shift to electric heating and cars.

Indeed, the appropriateness of the solutions needs to be considered in more depth. For example, IHS Global Insight's report notes that at the moment, for UK domestic customers, it is the 'wet appliances' (washing machine, tumble drier and dishwasher) which have the most potential to be time-shifted into the night hours. However, none of these appliances are silent and given the trend towards smaller dwellings and the EU drive to improve night time noise levels, time-shifting these activities may not be attractive to the public, or indeed in the interest of public health.

Q 9: Are there other measures that the Government should look at?

Daily electricity demand profiles such as illustrated in Chart 4.1 are predicated upon current daily working patterns. It seems reasonable to expect that changes in telecommunications, more flexible working practises and changes in family leisure time (away from family television viewing towards internet-driven activities, for example) might contribute to a less peaked electricity demand. We believe there would be some merit in the Government looking at potential macro changes in lifestyles which might impact on how energy is utilised.

An efficient retail market will be a precondition for optimal substitution, and the nature of substitution implies that other sources will be available during shortage of power. The electricity market includes price signals in real time and hours ahead, so it is conceivable that an intelligent demand could optimise electricity consumption serving the interests of both consumers and society. But, we emphasise, realising this outcome will not be straightforward.

Q 10: What are your views on the costs, benefits and risks of smart demand as set out above? Are there others?

The marginal benefit of additional demand response will depend on the share of wind power, and this increasing share of wind power is the consultation text's accepted justification for an increasing demand response capacity. However, the calculations seem to be based on a stable time-of-day pattern for the capacity balance. At 20% wind energy (as in Denmark) this pattern may be disturbed to a significant degree, and different analyses may be required.

The cost of increased flexibility necessary to accommodate the intermittency of wind energy will be high. A trade-off between curtailed wind energy and cost of additional measures might be found, but the cost of a more integrated and more intelligent energy system should be seen as a long term infrastructure investment, with major implications, not as a riskless, no regrets, quick fix.

Q 11: What are your views on the barriers to customers providing smart demand? Are there other barriers?

The installation of smart meters is just one step on the road to a smart grid. There is a current debate in Denmark if the signals to customers should be price signals or control signals. In any case, consumers cannot be supposed to make decisions every day based on signals from the grid. Intelligent appliances need to be able to receive signals and optimize operation.

It is understandable that National Grid would like the certainty of knowing what the response to a certain signal will be, which makes the role of aggregators as a potential responsible party, as described in the consultation document, potentially valuable. Traditionally we have viewed generators as commercial parties following schedules and commands. By contrast, electricity demand is a result of decisions by millions of decision makers, and therefore the prediction of demand behaviour is based on statistical evidence. Experience on demand response could be established by similar methods.

Q 12: What measures could be taken to overcome the barriers to smart demand? What are the costs and risks of these measures?

Obtaining detailed information on electricity demand profiles and potential for time-shifting is important (see the response to Q7). We also believe that it is particularly important to obtain information on embedded wind generation and its impact upon demand profiles. In our response to the National Grid (NG) consultation we suggested that NG requires wind developers to supply the SCADA (Supervisory Control and Data Acquisition) system data collected by wind farm site operators to NG or a Distribution Network Operator (who could aggregate and pass on to NG) as a pre-condition to obtaining a grid connection.

The development of a suitable retail market design should be given a high priority.

Q 13: What are your views (and any evidence) on the supply side measures? In particular, for each one, your views on:

- **Its potential benefits and costs**
- **Any issues arising from the measure for security of supply, carbon emissions reduction, or the Government's other objectives**
- **How the option might work in practice**
- **The need and likelihood for further technological development, where relevant**
- **Any regulatory or other barriers that should be considered**
- **Whether the Government should consider the measure further**

The development of a suitable retail market design should be given a high priority.

Q 14: Are there other ways of maintaining security of supply or supporting low carbon investment, given the challenges for the electricity system identified, that the Government should consider and how might these work?

Capacity mechanisms will be an important and difficult issue. It will be particularly difficult to determine the proper composition of capacity and to encourage producers to develop their capacity correspondingly.

One avenue deserving further consideration is the extension of the present practice of National Grid in the purchasing of spare capacity in the form of the standing reserve scheme from such as Wessex Water.

Wessex Water operate about 30 standby diesel generator sets of total capacity 20 MW, each set of typically 0.25MW – 1.2MW. The availability of the capacity of these sets is sold to National Grid and can be reliably on line in 4 minutes under contract to NGT Reserve Service. NGTs target is for all such generators to be on line within 20 minutes with which it is easy to comply. A diesel can be on full load in a matter of 20 secs if necessary. Large standby plant can take a lot longer than 4 - 5 minute to be on line and fully loaded. The sets typically are called for a few hundred hours per year, for several hours at a time under Standing Reserve.[6]

These generators synchronise and parallel with the mains automatically. Starting is initiated for these sets is by an electronic land line signal direct from NGT, and this is sent onwards via auto diallers to start the sets via a master PC. Once running their output is polled by the master PC and reported back to National Grid automatically. Within the NGT Standing Reserve scheme there could be potentially some several GW of such plant potentially connectable following

[6] This idea surfaced at a One day Conference at the Open University on Tuesday January 24 2006 on "Coping with variability: **Integrating Renewables into the Electricity System"**

modifications to their controls that are already built and installed in locations like hospitals, large offices, police stations, barracks, airports, and the like.

The hardware cost (cost of synchronising gear, breaker changes, modems and other modifications) of making this capacity available is typically about £10–50/kW for a 1 MWE set, compared to, say, £100 - £300/kW for a conventional large plant.

It would seem that this would be a cheap and effective method of coping in the near future with any large fluctuations in renewable generation output – primarily because the generators already exist, and it is believed it would be cost effective to make them available on load. A technical report by properly qualified Consulting Engineers would be appropriate for the further assessment of the scheme.

Q 15: What evidence and analysis do you have of the need for, costs, benefits and risks of these?

We have no special knowledge not available to the Department through other channels. However, we are concerned that in assessing the costs and benefits of a capacity mechanism the Department may employ traditional but now outdated concepts of the Value of Lost Load (VOLL). These concepts were correctly grounded in the interests of major industrial energy consumers, but VOLL is now related to wider societal interests such as national security, traffic management, the maintenance of electronic banking systems, telecommunications, water supply, indeed to social order in the broadest sense. In this connection, we note that population density in the South-East is now 432 persons per km^2, and is comparable with that of Puerto Rico (445/km^2). It is our view that UK is extremely intolerant of lost load, and that this is a relevant consideration for Government when assessing the costs of any capacity mechanism.

Annual Demand 427 TWh	**Annual Demand 427 TWh**	**Annual Demand 427 TWh**	**Annual Demand 427 TWh**
	Baseline High 10%	North Wind High 20%	North Wind High 30%
	TWh	TWh	TWh
Onshore wind	17.9	39.3	60.6
Offshore wind	12.2	33.6	54.9
Total Wind	30.1	72.8	115.6
Other Renewables	12.6	12.6	12.6
Total	**42.7 = 10%**	**85.4=20%**	**128.1=30%**
	GW	**GW**	**GW**
Peak Demand	**75.7**	**75.7**	**75.7**
Conventional Capacity	**74.0**	**72.0**	**70.5**
Onshore wind	5.3	11.6	17.8
Offshore wind	4.6	12.4	20.2
Total Wind	**9.9**	**24.0**	**38.0**
Other Renewables	**1.6**	**1.6**	**1.6**
Total Renewables[7]	12.8	26.9	40.9
CHP	12.0	12.0	12.0
Total capacity	**98.8**	**110.9**	**123.4**

[7] Other renewables should be larger to balance the arithmetic

http://www.nationalgrid.com/uk/Electricity/Operating+in+2020/2020+Consultation.htm