SUBMISSION FROM SIR DONALD MILLER AND MR COLIN GIBSON

1. Summary

In this submission evidence is provided on the security of electricity supplies in Scotland under the four headings requested but we also comment on related aspects, not raised by the Committee, which impact on the robustness of supplies in Scotland. It is vital that measures are taken to safeguard supplies (principally the retention of adequate capacity at Longannet until such time as these matters have been fully studied) and in order to buy time for the construction of new base load plant to replace the thermal stations (Longannet and Peterhead) as well as the two nuclear stations at Hunterston and Torness.

The present difficulties stem in large part from the structure of the electricity supply industry following privatisation and these will not be adequately met by the 2014 Energy Bill, the more so as this does not address the particular problems in Scotland. Therefore we recommend that in the absence of these problems being addressed nationally, the Scottish Government, for the benefit of consumers in Scotland, seek powers to adjust the responsibilities of the Industry and the Regulator in Scotland. Finally we make suggestions as to the form that these changes could take in the interests of securing reliable and economic electricity supplies for the future.

2. Introduction

The problems facing electricity supply in Scotland in the coming years cannot be examined without first considering the electricity situation in the UK as a whole, especially as Scotland under present energy policies will be increasingly dependent on imports from England.

Under the Electricity Acts, the supply Boards (CEGB, SSEB and NOSHEB) had an obligation to supply and to meet this, provided a generating capacity margin above winter maximum demand of some 20-24% with a higher figure for seven years ahead of 28%. This was equivalent to a loss of load probability of four winters in 100 years. In order to fulfil this obligation at the lowest practicable costs to the consumer, the Boards carried out regular 'whole system cost' studies of a wide range of strategies to determine the most attractive investment strategy.

At privatisation, the responsibility for ensuring security of supply became unclear, it being assumed that 'the market would always provide'. Ofgem, while their terms of reference include 'security of supplies', appear to have interpreted this as only ensuring DECC's objectives for renewables are met. National Grid's responsibility is limited to making the best use of plant offered by generators to meet demands. Likewise the use of whole system cost studies was abandoned, with DECC, amongst others, resorting to quoting the less meaningful 'Levelised Cost of Energy' for specific types of generating plant. This approach ignores the well-known interaction of different types of generating plant in an integrated electricity supply system and fails to distinguish between the requirements and costs of meeting system maximum demands as distinct from energy requirements. Governments, over the years, have made major adjustments to the system adopted at privatisation and continue to do so but without addressing the fundamental weaknesses of the structure.

UK Government targets for reducing CO_2 emissions from the electricity system require that some 45% of electricity be generated from renewable generation by year 2020. To achieve this target would require some 35GW from wind. However there is a strong possibility that these targets will not be achieved and it will perhaps be helpful to examine the Committee's questions against the background of the most likely out-turns. National Grid, in their studies of future energy scenarios examine four different compositions of load and generation, dependent on factors such as economic growth, progress with renewables and energy savings as well as the adoption of new types of load such as electric cars, heat pumps etc. We have taken the average of the four scenarios to arrive at a likely scenario for the purpose of this submission- see Appendix.

Against this background our responses to the questions raised by the committee are as follows:

3. Supply

As the figures in the appendix show, the plant margin in the UK for year 2020 is expected to be some 12%, well below the pre-privatisation figure of 24%, and reliance is placed on 2,700 GW of demand side management to achieve even the low margin of 17%.

The Scottish Government's target to generate renewable energy (mainly from wind) equivalent to 100% of Scotland's consumption by 2020 would require an installed capacity of some 13.8GW. Some 7GW is now operational and a further 9 GW has planning consent , more than sufficient to meet the target, but the Government has so far been silent on the implications of this excess capacity for their energy policy.

The question of how peak demand in Scotland, currently some 5,500 MW, will be met during the frequent occasions when wind output is low has not apparently been addressed, presumably on the assumption that electricity will be available to make up the shortfall as and when required over the interconnectors from England. As the figures in the appendix show the UK plant margins are too low to guarantee reliable supplies in 2020 and through to 2030 even on the assumption that substantial demand management is achieved.

In Scotland both Longannet and Peterhead are under threat of being withdrawn from service principally as a result of being constrained off the system by wind power which is given priority. Without these stations there is an effective installed capacity of dispatchable generating plant in Scotland of some 4,000 MW (or some 3,400 MW after allowance for 'loss of availability'), well below Scottish winter maximum demand. It should not be forgotten that some 2,000 MW of this comprises the nuclear stations at Hunterston and Torness and it is most unlikely that two such stations using the same basic technology and reactor designs would have been constructed in the absence of Longannet.

4. Demand Management

The scope for further contributions from demand management is limited. The costs to commercial and industrial firms of an interruption of supply and the consequent cessation of their activities is with few exceptions far in excess of any savings made from the lower prices for an interruptible supply. The exceptions to this are generally heavy user process plants such as some chemical plants with moderate labour costs and the ability to store their product, but we would expect that nearly all of these which can accommodate an interruptible supply already do so. In the domestic market, dual-rate tariffs used to encourage consumers to move load to off-peak times (storage heaters, washing machines etc.) were widely used, but with electric storage heating now in decline and with high noise transmission in modern housing making the use of machines at night impractical, these are not expected to result in a significant degree of demand management, as a result of the wider deployment of smart meters.

There remains the possibility in the longer term that developments in types of electrical load, such as charging for electric cars or widespread adoption of heat pumps for heating, would be more amenable to management of demand but there can be no possibility of these having a significant impact by 2020 or even 2030.

It seems more probable that the rapidly escalating costs of electricity, largely as a result of energy policies, will be the chief restraining factor in limiting demand growth. In this connection we estimate that if the UK Government renewables target were met in full, the additional cost in 2020 would amount to some £12 billion, equivalent to £172 or 25% on the average domestic consumer’s bill. Commercial and industrial consumers each face similar costs, but augmented in their case by the higher VAT rate. The bulk of these costs to commercial and industrial consumers will eventually also fall to the domestic householder in the higher costs of goods and services. To all these have to be added the costs of carbon taxes which, based on the prices in the 2014 budget, would add a further £50 to the average domestic consumer’s bill by 2020. Adding these various elements of the energy programme results in the astonishing increase in household costs of some 90% by 2020, expressed as a proportion of the average household electricity bill. Nor is this the end of the matter as costs of energy with the planned renewables programme will continue to rise in the years ahead.

5. Transmission

Under the present structure, the transmission Companies (National Grid, Scottish Power and Scottish and Southern) have responsibility for proposing and constructing new transmission. While they benefit from the increased cost base in their charges, all of these charges eventually fall to the consumer. While these investments require approval from the Regulator it is not clear what criteria Ofgem apply in the interests of the consumer.

The reduction of conventional generation in Scotland (whether by withdrawal from service or being constrained off by wind output) coupled with the need to export considerable quantities of wind power from time to time over the inter-connectors to England will introduce voltage control problems and greatly reduce the robustness of the system. To mitigate these problems the transmission companies are to introduce some 900 MVAR of shunt and series compensation devices on the interconnections and have also contracted with SSE on a short term basis (to 2017) for voltage control services from the Peterhead CCGT station. There is no indication that plans are in place to secure supplies in Scotland beyond 2017 or for the six years or more required to construct major new generating plant.

The existing firm import capacity of the inter-connectors is quoted as 2600 MW provided there are adequate voltage control services and this figure will be increased to some 4000 MW with the commissioning of the High Voltage DC link from Deeside to

Hunterston planned for 2017. Until such time as this DC link is established, there is a high risk of failure to meet demand in the absence of Longannet and Peterhead. Moreover without the nuclear generation, capacity is clearly inadequate to meet demand later in the 2020's. There is the further problem that the absence of conventional generation in the Central Belt will result in an increasingly brittle system, more liable to major shutdowns in the event of faults . This is discussed further in section 7.

We see no relief from this situation in the provision of inter-connector links to European systems. While it is sometimes claimed by proponents of renewable generation that widespread interconnection of electricity systems across Europe will effectively guarantee firm output from intermittent sources of generation, this is not supported by detailed analysis. In fact, as a recent study by Dr Capell Aris shows, the frequency of large anticyclonic weather systems covering the whole of Europe are such that low wind outputs in the UK are frequently coincident with similar low outputs throughout Europe, so that even large scale interconnection would make a minimal contribution to security of supply. We note that a report by consulting engineers Poyry for DECC concluded that when plant margins are low in the UK, power flows on interconnectors with Europe reduce margins just as frequently as they improve them. We also note that National Grid in their Ten Year Statement do not take credit for continental interconnections for meeting system maximum demand.

6. Capacity Market

The UK electricity structure at privatisation is unique in electricity systems in that it failed to recognise the vital necessity of providing generation capacity sufficient to meet maximum demand or providing an optimum mix of different types of generating plant in the interests of the consumer. The UK government has belatedly attempted to remedy this by inviting tenders for the provision of capacity for some years ahead. However in the auctions to date little or no recognition appears to have been paid either to the types of plant or their location on the system, both of which carry very significant costs for the consumer. Nor is there any indication that planning is being undertaken on the much longer time scale required for the construction of major new generating plant.

In our view Government is not equipped to fulfill the role of detailed planning of the electricity system and it seems clear that when inviting bids for new plant, they are in a weak negotiating position. This became apparent in the contract negotiations for new nuclear capacity at Hinckley. While the price agreed was similar to the published expected out-turn cost for the first plant being built by EDF in France at Flamanville, we would have expected a significant reduction for a second plant of virtually the same design provided from essentially the same supply chain. Certainly these costs are a third higher than those published by the USA Energy Administration for equivalent nuclear capacity now under construction there. Furthermore there is no possibility that SSEB or NOSHEB would have let contracts for new nuclear plant with a Company which is ten years and five years late on their two existing contracts and with a main contractor who is reported to be under severe financial pressure.

In our view, the 2014 Electricity Reform Act, with its confusion of responsibilities and its weakening of financial disciplines, is unlikely to be successful in achieving satisfactory outcomes for the consumer.

7. Other Matters

Voltage Control

We note that with the Transmission Companies plans there will be several automatically controlled devices between central Scotland and the English border all taking their input signals from system voltage and operating to control the voltage in one form or another. These controls comprise: shunt and possibly the series compensation, generator voltage regulators and stabilising devices. To this will soon be added the control systems on the DC link converters . This is an unusual situation and we are not aware of any similar regime on any other electricity network. It raises the question of uncontrolled interactions between the various control devices.

It is known that MVAR compensation devices generate harmonics and also high frequency torque variations that can, in adverse circumstances, result in failure of generator shafts. There have been instances of this abroad affecting both large conventional generators and wind turbines. The problem is more likely to affect machines which are electrically near to the devices either physically or as a result of series compensation reducing the effective overhead line lengths.

As well as the crucial importance of voltage conditions on the inter-connectors to maintain import capacity from England, the system in the North of Scotland, with its proliferation of wind turbines is also becoming increasingly vulnerable. Unlike conventional generators, wind generators are mostly various types of induction machines some of which make heavy demands on the system for magnetising current and all risk causing system voltage collapse under fault conditions.

Black Start

It is standard practice for electric utilities to have plans in place for recovering the system in the event of a complete shut down. Here Longannet with its larger capacity has a crucial role to play. While it may be possible to achieve a black start using the pumped storage stations in conjunction with the hydro stations, this would be a lengthy procedure, possibly of some days. By comparison, the use of Cruachan in conjunction with Longannet is straightforward in that it can rapidly provide a supply to the Central Belt sufficient to start all four sets at Longannet enabling a black start to be accomplished in the minimum time.

It is our view that neither Peterhead because of location and limited capacity nor the nuclear stations (subject to loss of reactivity from xenon poisoning for some hours following a shut down) could effectively substitute for Longannet in this connection.

Dynamic Performance

This refers to the ability of the system to remain stable by damping the naturally occurring oscillations of the generating plant which result from small changes in system loading or operating conditions. The oscillations have typically a natural frequency in the range 0.5 - 1.0 cycles per second and occur when the synchronising forces, which keep the generators in step, are weakened as a result of heavy loading across long transmission links.

Such oscillations were experienced on Scottish generators with the beginning of heavy exports to England and Wales in the late 1970's and were sometimes sufficiently serious to require reducing the exports. Following system tests in the early 1980's power system stabilisers were fitted to certain of the large sets in the Central Belt and Peterhead. These, while not eliminating the oscillations, provided sufficient damping to allow the exports to continue.

While the installation of MVAR compensation at the midway points on the west and east interconnections will improve matters, the loss of major generating units in the Central belt and their substitution by a large amounts of wind turbine capacity, much of it in the North of Scotland, can be expected to greatly aggravate the problem.

Transient Stability

This refers to the ability of the system generators to remain in synchronism (stay in step) and to supply system loads following a fault. The fault will be detected by automatic protection systems and the faulty equipment disconnected in under 0.15 seconds but the greatly reduced ability of the system to transmit power during this period results in rapid acceleration of the generators at the transmitting end and deceleration at the receiving end. The ability of the system generators to remain in synchronism following the clearance of the fault is very much a function of the inertia of the generators; for example additional inertia is frequently added to hydro generators where they are required to transmit over long distances to the load centres.

Wind generators, being in the main of the induction type, have no inherent ability to contribute inertia to the system and the transmission of large amounts of wind power over longer distances from the north of Scotland over the Border would be expected to seriously degrade the transient stability of the system with greatly increased risk of system disruption and shut-down. Any loss of nuclear or conventional generation in the Central Belt would be expected to substantially aggravate this problem. Whilst the compensation systems to be fitted to the inter-connectors will be of some assistance in improving transient stability it is worth making the point that the DC link, whilst improving interconnection capacity will be less effective in improving transient stability in that unlike the AC system, its stabilising contribution does not increase once the fault is cleared.

8. Recommendations

There is no indication whether from DECC, Ofgem or the Transmission Companies that the questions raised here have received appropriate study. We note that SSE, in recent weeks, have advertised for Consulting Services (a three year contract at estimated cost £700,000) to assist them in carrying out system technical studies. Furthermore it is vital that whole system economic studies for 10-15 years ahead be re-introduced as it cannot be satisfactory that new generation be approved for construction as in the recent 'Capacity auctions' held under the Electricity Reform Act without proper consideration being given to its impact on the system or the effect on consumers' bills.

The present structure of the industry in the UK is defective in that none of the participating companies or organisations has a clear responsibility for securing the reliability of our electricity supplies, whether in the immediate future or for the six to ten years ahead which it takes to construct new generating plant. There is an urgent need for Government to appoint a competent body to examine the structure and obligations of the UK electricity industry but failing that it should still be possible for the Scottish Government (benefiting from experience in other de-regulated electricity markets), to take the initiative in the interests of Scottish consumers by pressing to secure powers to vary the modus operandi of the Industry in Scotland. Two effective changes would be to require suppliers of electricity to consumers in Scotland (whether or not they are generators) to be required to maintain a sufficient margin of capacity to secure supplies to their consumers and also for transmission operations and generation dispatching to be under the control of a 'not for profit' organisation.

At the same time consideration could be given to requiring the Regulator to approve a basic tariff available to all domestic and small commercial consumers. In the interests of openness and to put an end to the obfuscations which have been a feature of energy policy as it affects the electricity industry, the Regulatory Body should be required to publish a fully costed analysis of the basis for its decisions.

Sir Donald Miller, FREng, FRSE Chairman Scottish Power 1982-92.

Mr Colin Gibson, FIEE, Power Network Director, National Grid 1983-87.

Appendix

Figures from NG Future Energy Studies paper 2014

Averages of 4 Scenarios Summaries				
		Installed Capacities MW		
		2015/16	**2020/21**	**2030/31**
Nuclear		8,981	8,981	8,189
Coal		16,238	8,667	1,691
Gas		29,320	34,117	34,526
CHP		4,198	4,880	5,282
CCS		0	0	4,063
Interconnectors		4,000	5,500	8,650
Onshore Wind		7,903	12,537	16,185
Offshore Wind		5,041	8,703	21,378
Solar		4,129	6,624	12,630
Biomass		2,124	3,193	3,420
Hydro		1,672	1,672	1,672
Other Renewables		1,349	1,744	3,612
Other (including pumped storage)		3,572	3,499	4,095
Total Installed capacity (MW)		**88,527**	**100,117**	**125,393**

ACS Peak Demand		60,741	60,091	60,335
Demand Side Management		1840	2,700	2,525
Generation Capacities Adjusted to Equivalent Thermal Installed Capacities at times of Peak Demand				
	Adjustment Factor	**2015/16**	**2020/21**	**2030/31**
Nuclear	1	8,981	8,981	8,189
Coal	1	16,238	8,667	1,691
Gas	1	29,320	34,117	34,526
CHP	1	4,198	4,880	5,282
CCS	1	0	0	4,063
Interconnectors	0	0	0	0
Onshore Wind	0.1	790	1,254	1,619
Offshore Wind	0.1	504	870	2,138
Solar	0	0	0	0
Biomass	1	2,124	3,193	3,420
Hydro	1	1,672	1,672	1,672
Other Renewables	0.1	135	174	361
Other (incld. p/s)	1	3,572	3,499	4,095
Total Equivalent thermal capacities (MW)		**63,534**	**67,307**	**67,056**
Plant Margins		**Plant margins %**		
Target Margin		20	24	28
No Demand Side Management (DSM)		11.2	12.0	11.1
With Demand Side Management		14.7	17.3	16.0