National Grid Consultation – Submission by Derek G Birkett

Background Experience.

The author is a retired Grid control engineer having twenty years of operational experience controlling the Electricity Grid in the North of Scotland. Prior to joining system control, several years of experience with the operation of hydro and coal fired generating plant were acquired, all on shift duties. Related experience over a decade on project work was obtained with installation and commissioning at five power stations, three of which were Nuclear, as an employee of the CEGB and TNPG, attaining section engineer status. A degree in electrical engineering from Leeds University led to the award of Chartered Engineer with this project involvement.

Introduction.

The productive absorption of intermittent renewable energy on the GB Grid system is a technical issue where expertise in confined to a few score of individuals. This agenda has been forced on the industry by political pressure against all economic criteria and without technical guidance. The scale of subsidy introduced by Government policy has created extensive distortions into a market where commercial and political considerations override technical good sense. The issue in hand is how to accommodate the scale of intermittency with renewable generation without compromising system security.

Basic Principles.

A glance at first principles would not be out of place. Predictable generation has always been the foundation of ensuring system stability. The time worn principle not to encourage uncontrollable generation has been jettisoned. The consequence of renewable investment is increased volatility, flouting the principle of minimum adjustment to ensure smooth running of the Grid system. Already on average, almost fifty loading adjustments each hour are exercised for system balancing alone with all the consequential cost of maintenance, plant deterioration and reliability. With increasing renewable investment, these adjustments would not be linear but exponential in character forcing a retrograde ‘fly by wire’ or automatic system of control to be implemented. Once introduced the manual system would rapidly degrade, creating reliance on automation with profound implications for fault retrieval situations and back up reliability. The consequence would be further exposure to risk.

Certain techniques could avoid this unwanted measure. Renewable tidal energy with its predictable cycle is a promising technology but demands disciplined exploitation. A combination of the various technologies could be dovetailed to eventually create a constant generation output throughout the twenty-four hour cycle enabling a stand-alone facility that could be largely independent of the plant scheduling process. A similar approach across the border interconnection to Scotland would maintain constant power transfer by combining wind, hydro and pumped storage into a combined generation mix. Another technique would be to reinstate a merit order of generation based upon plant response and running costs and not on market price signals. Increasingly it is the response capability of the balancing source becoming the critical determinant. Currently the market tail wags the generation dog. Such new thinking has to come before automated response.

Minds should concentrate on the effects of system failure that whilst currently statistically insignificant, when they do occur have devastating impact. There is a human factor with exhaustion or pandemic with irreplaceable specialist staff. The extended loss of power supply to a major city has consequences far beyond any narrow commercial consideration. I am reminded of the final report into the system incident of the 27th May 2008 when no recommendation was made to increase response and reserve levels, based on the economic case with clause 6.5. The cost to the consumer was utterly ignored. There is an ethical dimension lacking, all too prominent with the recent turmoil in financial markets.

Generation Scheduling.

The principal scheduling challenge to accommodate both fluctuating demand and wind resource is to have sufficient response capability available to overcome the most extreme fluctuations that could be anticipated. Forecasting has limited application, as contingency is the necessary requirement. Sufficient experience of wind fluctuation can be accessed from continental experience with allowance being made for Atlantic exposure. A good example came on the 29th October 2000 in Denmark when a 41% swing with an installed wind capacity of almost 2GW arose within an hour.

The system is most at risk when unexpected events coincide, often prompted by severe weather conditions. This is not confined to transmission trips or generator loss but also communication and equipment failure. In the past the latter events, though rare, were often ridden through, being at times of relative inactivity that existed throughout most of the twenty-four hour period. This circumstance no longer holds and increasingly loading or balancing adjustments have become a continual and intense activity. Recourse to statistical techniques to determine probability of events often belies the operational reality of having to keep some contingency reserve, not simply as a ‘just in case’ scenario but the consequential awareness for any remote risk of failure. Sophisticated modelling aids have to accommodate the bigger picture. All too easily such aids can become an operational constraint.

With loading response, comparison is often made between meeting system demand excursions and wind volatility to justify system accommodation. The nature of response with both cases is quite different. Predominately demand excursions can be predicted with some degree of accuracy based upon past experience. This is not true with wind volatility as events are much less predictable, more frequent with scale unknown and crucially the direction of movement uncertain. This last characteristic prevents anticipatory loading that is a crucial component with any loading response to a demand excursion.

Mitigating Intermittency.

As an independent witness at the Beauly-Denny Public Inquiry, a personal judgement was given with the level of wind resource on the GB Grid system at which severe problems of stability would become evident. This equated to the then current operational and consented wind capacity of around 6GW. This estimate is to some degree elastic and dependent upon the scale of investment allocated to the problem. Mitigation would primarily come from interconnection with other grid systems and additional pumped storage capacity. The former would have a political dimension as it could create a circumstance of one-way dependency upon the Continental Grid system whilst with the latter; surprise is expressed for not being advocated within the ‘gone green’ 2020 scenario. Recent intent of SSE to invest into further pumped storage capacity within the Highland region is entirely predictable.

Alternative means to mitigate intermittency are outlined in your consultation document. Scale and cost become prime determinants and are advocated as commercial alternatives. I would hope wider counsel might prevail.To chart a path with so many variables and uncertainties with system security, making refrigeration a tool for demand control, is to become hostage to fortune with excessive use and risk with indeterminate food quality deterioration. Likewise with electric car transportation where cost and risk is borne by the customer. The imposition of ‘smart’ metering for the domestic scene is more about access to meter reading (and remote disconnection?) than customer information and is not without considerable social implications. Once novelty wore off, habits of domestic routine would be re-imposed. The cost of modification (who would pay?) for dedicated circuits would confine such use to new installation, becoming a facility only in the long term. Another consideration is seasonal response from heating load where summer relief is almost non-existent. My view is that such techniques in the domestic sphere would provide very limited scope for system balancing unless heavily subsidised or subject to regulation.

The concept of variable costing (except for white meter) would be open to error and abuse without effective means of correlation from the consumer end. Would a third category of white meter control for the daily peak demand period not provide a more common sense solution for domestic customers with colour code identification for metering?

I would view micro generation on any scale with some concern having maverick effects with system faults and disturbances. It is not at all clear how this problem can be overcome without excessive and costly precaution. As with any new regulation, the time lag with full implementation considering scale, dispersion and derogation may last for years and without effective policing could never be achieved. The logistical and bureaucratic challenge would be considerable. The proposals of the Conservative party on microgeneration are seen as little more than commercial opportunism. The general public seldom factors specialist maintenance and repair costs into the viability of microgeneration. Heat pumps would appear to offer the best option for development but with limited scope for most domestic situations. Back feed tariffs do not entice.

A versatile means of managing intermittency is found with coal-fired generation that is expected to reduce significantly with the 'Gone Green' scenario and is a major economic casualty with Government policy. From a strategic perspective it is incomprehensible with having a secure fuel supply at home and abroad, reducing reliance upon CCGT generation and denying fuel option, so important with market pricing.

Of all forms of generation, conventional hydro has the most favourable characteristics and provides the most rapid rate of response even when idle. Although renewable, being capital intensive has deterred its exploitation yet an estimated 0.5GW of further large hydro (with storage) could be constructed with any long-term perspective. The low availability statistic of 60% as given in para 6.55 is grossly misleading. This derives from its annual load factor with run-off and de-rating of certain plant in cascade to qualify for ROC payment. Reliability is exceptional and storage enables flexible regimes of operation throughout the year, if exercised in moderation. It has potential for system balancing with fluctuating capacity available when day before notice is given.

Embedded Generation.

The proliferation of wind resource as dispersed embedded generation on the scale being promoted has many concerns. These issues come to light with the report on the 27^{th} May 2008 Grid incident where the scale and content with discrepancies between the preliminary and final reports suggest an emasculated role of National Grid to monitor real time events than previously. Comment on the preliminary report is made as an appendix, leaving many questions unanswered within the final report. Predominant is the role of embedded wind generation to influence the third drop in frequency, leading to low frequency relay disconnection of consumers. The explanation discounting this effect is unconvincing. A related issue is the apparent lack of support from the Dinorwic pumped storage facility for this incident. This drives the need for further pumped storage capacity to avoid the dependence upon a single dominant station location that is independent of the cross border interconnection to Scotland with its stability constraint.

A problem touched on previously is the scale of derogation and observance of Grid Code compliance with the extent of dispersed wind generation plant through a multitude of DNOs with no direct incentive to comply. This is compounded with wind farms in England not being subject to the Grid Codes below 50MW capacity. Policing of developers seems to be confined to the time of commissioning. What incentive is there to comply and what penalty exists for non-observance? The extensive replacement programme of wind turbines in Germany provides ample opportunities for secondary deployment within the UK. Just how extensive is the derogation for existing wind turbines on the GB Grid system?

A major recommendation by the UCTE following the continental grid incident of November 2006 was that all distribution connected generation should have the same behaviour during frequency and voltage variations as for units connected to the transmission network, becoming retrospective. In addition system operators are to receive on-line data of distribution connected generation. These conditions are not applied across the GB power network system; the monitoring of wind output for England and Wales to the system operator with onshore wind is not evident. Future proposals and organisation with offshore development should introduce a much-improved rigour for Grid Code compliance.

The scale of wind resource proposed introduces much greater risk for system splits to arise, particularly from Scotland. To enable reconnection in manageable timescales, volatility with frequency would become a serious problem. To disable grid connected wind farms in a controlled manner over forty-five minutes still leaves embedded generation. In storm conditions such volatility would become extreme. How is this to be managed, raising the prospect of pre-empting the problem in extreme weather conditions by shutdown at considerable cost. In practice the problem and risk would no doubt be endured.

Stability of remote wind resource.

Transmission design assumptions for wind resource give a dispersion factor of 60%. Coupled with proposals to share capacity for low load factor generation, reduced risk of trip criteria and the premature connection with 450MW of Highland wind capacity, these items would introduce constraints with summer gale conditions. Intertrip schemes may well be deployed. Performance with voltage regulation (and uniform frequency response) with any scale of wind resource may be problematic in areas with little consumer demand as anchor and derogated capacity. The technology is quite recent and unproven on this scale. This circumstance is rapidly evolving and therefore prone to the unexpected. The issue of uniform frequency response and voltage regulation for wind turbines seems to be a critical determinant for National Grid in accepting the scale of wind resource proposed where reliance on conditions contained in paras 5.21 and 5.24 would be critical.

Transmission

The ambitious proposals contained in the recent ENSG document have assumed an unlimited absorption of over 30GW from wind resource. Has any recognition been taken for contingency planning if this target, for whatever reason, were not found to be feasible? A good example arises with the Beauly/Denny project that is not required for 2020 renewable targets. Its construction would allow wind farm development across the southern Highlands thereby desecrating the landscape that supports tourism. An east coast alternative is available with upgrading that would ultimately constitute part of the final transmission scheme post 2020. The capability of this line cannot be realised until the restriction with the border interconnection is resolved. This interconnection has a far greater priority for any GB System upgrading and is a prime source of excessive constrained off payments. This item is the tip of a very large iceberg. Are the investigations with SQSS standards in para 4.40 to accommodate 1800MW disconnection intended to cover Scotland?

Reliability of Generation and Estimates.

As already stated, response capability would become a critical issue for accommodating intermittency. There are several developing constraints:-

* The retirement of plant with the LCPD regulation.
* The increasing age and reduced reliability with fossil plant.
* The increasing predominance of CCGT generation for responsive use. This has exposure to type faults, gas supply constraints and reduced on line flexibility.
* Reduced nuclear contribution with declining reliability.
* Increasing operational activity reducing overall long-term reliability.

The current estimate of 3% for managing residual demand can be expected to become much larger (as recognised) from increasing levels of microgeneration and embedded generation with significant implications for control techniques.

Availability of Resources.

As a consequence of inadequate Government policy over the past two decades the current mix of generation plant is seriously out of balance to accommodate construction timescales, an ageing profile and resilience against cost fluctuations. This has coincided with a policy of uneconomic renewable development, primarily that of wind resource that is 'additional to', not 'replacement for' (HofL Renewable Inquiry) the necessary investment with fully controllable conventional generation plant, all having their individual range of complementary characteristics. This scale of necessary replacement is without precedent, compounded by regulation that constrains economic choice. Together with constructional programmes throughout Europe, competition for resources of capital, manufacturing and technical skills are expected to be strong in a seller's market. This at a time when credit is restricted, the manufacturing base in the UK has shrunk and apprentice training neglected. With nuclear construction considered as an important component of this essential commitment, substantial investment over most of a decade will be necessary before any energy is produced. Overall this circumstance is a recipe for project delays and cost overruns. In terms of energy supply and economics, logic would question the role for renewable investment, particularly when it undermines the economic case for new conventional standby plant. Insufficient margin with total generation capacity only compounds the increasing problems in handling intermittency. The gravity of this whole situation is not being adequately addressed.

Information Transparency.

Historically National Grid had claimed a 35% load factor for GB wind resource that with recent analysis from Ofgem ROC returns now indicate a value of around 26% (the Gone Green scenario has assumed 35%). Allowing for significant offshore development, current estimates now promote 30% load factor that seems optimistic. These figures are of far reaching consequence with the initial justification for investment and planning approval, return on investment, establishing a capacity credit to offset against system peak generation requirements and not least the eventual plant capacity required to meet EU and UK renewable targets.

Further transparency is needed to reveal costs to the customer of not only the Renewable Obligation subsidy needed to promote expansion, representing a fraction of the overall cost from having a renewable agenda but related expense with investment into transmission connection and reinforcement, system balancing needs, standby plant incentive and constrained off payments to generators as compensation for transmission restrictions.

Cost estimates in the past have not inspired confidence and cannot be relied upon, in particular when a specific agenda is being promoted. Without such information the full consequences of energy policy cannot be evaluated as a basis for change. In the long term no policy is immutable.

Conclusion.

The combination of technical change, uncertainties, developing constraints and necessary scale of generation replacement, coincident with having to manage increasing intermittency, presents a scenario of unacceptable hazard. When set against the consequence of failure, any assessment of risk should adopt a cautionary principle. With decades of past system stability taken for granted, this departure from sound practice, driven in a climate of excessive subsidy, haste and recession, presents a test of nerve where no clear overriding technical authority exists. The circumstance for commercial gain is evident, institutional pressure must be intense.

Any historical perspective would question the imperative of man-made climate change with so much scientific dissent when the premium is so ruinous and potentially destructive. Reduction of carbon emissions from renewable generation when placed into global perspective has limited effect when set against deforestation and energy savings. The need for energy security by becoming less dependent on imported energy is more persuasive but the means chosen would integrate this goal into a European entity whilst enfeebling national economic strength to influence events within that entity.

This judgement of unacceptable hazard comes from a background of twenty years experience with direct operational system control, the behaviour of frequency conditions being a constant reference with all loading instructions. The imperative of maintaining system balance is evident but the vulnerabilities and risks are not. This cavalier approach in dismissing operational knowledge for institutional gain will bear heavily in years to come. Such frankness as explained can only come from a retired position.

Derek G Birkett 24th July 2009

Appendix. Observations with the National Grid Investigation into disconnection on 27th May 2008 (dated 28th July 2008).

Observations with the National Grid Investigation into disconnection on 27th May 2008

Introduction. Government decision to target over 30GW of renewable wind capacity must have had confidence that the GB Grid system would be able to absorb this level of intermittent resource. The incident of 27th May, when an estimated 580,000 consumers were disconnected, raises questions whether this confidence can be justified. The need to establish the cause of this incident cannot be over emphasised and is an issue of major public concern with significant economic and political consequences.

Summary. This undated report is hobbled by addressing the concerns of BERR/Ofgem as distinct from a public need to address all issues relating to this incident. There is no indication that a final report will follow and significant uncertainty surrounds critical areas of information to explain the third loss of generation leading to consumer disconnection. No explanation is offered for the extraordinary series of generation losses and the obvious role of intermittent wind resource to influence this incident. Such is the emasculated role of National Grid, critical items of information have not been provided to enable a full analysis of events. So sensitive is the nature of this incident, no meaningful causes are explored or suggested. The recommendations made are limited to information supply from participants

Generation.

1. It is uncertain whether Generator A tripped or was shutdown with notification.

2. Was any preliminary warning given with risk of trip for Generator B?

3. No location or status of generation loss is provided, only capacity. This denies any analysis of trend, reliability or cause, however limited.

4. The role of fast acting response information with pumped storage is not acknowledged or detailed. This would normally provide an immediate corrective response with any large generation loss. There is an installed pumped storage capacity of 2.8GW on the GB system of which 700MW is located in Scotland.

5. The Scottish component of pumped storage would have been constrained by the border transmission limitation as described in 4.1.4 thereby denying any potential contribution towards frequency recovery.

Wind Resource.

1. No reference is made in this report of wind resource becoming a defining factor for this event. The word ‘wind’ is not mentioned, only reference to distributed generation where absence of information from DNOs is acknowledged. (5.5.4). Paragraph 6.2.1 does state that this information is vital to explaining the full facts of the incident.

2. No meteorological conditions are given to suggest any variation of wind output or consumer demand.

3. There is no reference to 870MW of grid connected wind resource from Scotland being monitored by National Grid. (From the listed locations a figure 100MW less is suggested. Three attempts were made to establish if this monitoring was recorded)

4. BWEA website indicates the GB Grid system has 2.3GW of connected capacity. The National Grid SYS for 2008-09 states 3.8GW although this is an anticipatory figure of which 1.6GW is Scottish grid connected capacity. England and Wales has no such Grid connection for wind resource where grid voltages are at a minimum 275kV.

5. A consideration affecting wind resource is the extent of derogation from recent Grid code modifications, given the scale of previously installed capacity.

Frequency Response (fig 4).

1. The third frequency drop from 49.14Hz as described in 2.2, 4.3.1 and 4.3.7 suggest a misleading drop of 250MW. However 5.2.2 indicates this as being tripped DNO embedded plant even though being two minutes after the second major frequency excursion. This third frequency drop suggests around 600MW of generation loss that has yet to be explained (5.5.4).

2. The operation of low frequency relays to give a consumer demand loss of 581MW as described in 4.4.3 and 5.3.2 is considered to be suspect. Has any corroboration of frequency conditions been sought from alternative locations? Even though governor reaction to a rise of frequency would depress total generation, instant demand loss of that scale would have expected a sharper correction (5.3.3).

3. With any severe jolt to the Grid system it is inevitable some tripping of generation plant will result, especially with non-synchronous items with low rating capacity. The difficulty of recording this effect on the scale required is logistically fraught, even though a requirement from DNOs (5.2.1). This circumstance provides a powerful argument against deploying micro-generation on any scale. Such tripping would be immediate in effect and not expected to influence the third depression with system frequency that comes two minutes later (4.3.7).

4. A component of pumped storage is normally kept in spinning mode (synchronised to the system) to automatically generate full load at 300MW with a drop in frequency below operational limits. Further pumped storage capacity called on manually could well have synchronising delayed by turbulent frequency conditions. This effect would also influence the automatic introduction of OCGT generation as described in 5.1.5.

5. Even though consumer demand for this period would be expected to be relatively static, the uncertain data provision as described in section 6 would deny any attempt at ‘balancing’ to establish an effect from a wind excursion. The recovery of frequency for the combined input of OCGT generation about 500MW (5.1.5) and the onset of demand control estimated at 1200MW (5.4.1) appears to be sluggish.

Single Event Loss.

In outlining the framework of infeed loss risk at 3.1.3 the suggestion of normal loss at 1000MW is made with infrequent loss at 1320MW. This is misleading, as can be seen in Figure 9 where plant loss regularly exceeds 1000MW. A decade ago a loss of 2000MW was experienced with the loss of the French interconnection without breaching statutory conditions.

UCTE Recommendations.

Following the Continental Grid incident of 4th November 2006, the technical authority UCTE (Union for the co-ordination of the Transmission of Electricity) in recommendation 5 of their final report required TSOs to have control over generation output with ability to start/stop units. For generation connected to DSOs, on line data of connection to be received by TSOs. The requirements for response of generation units with frequency and voltage variations, to be the same for both transmission and distribution connected generation, becoming retrospective.

In view of the absence of status from DSOs with distribution-connected generation for this incident and probable logistical difficulties with provision, the above recommendation should become a pertinent issue for future examination.

Analysis. The unexplained third drop in system frequency can be deduced from limited options. These are:-

a) Consumer demand pick up (highly improbable with summer conditions)
b) Rogue loss of large-scale generation. In this event an omission to report a variation on this scale would be highly culpable and detectable.
c) Loss of small-scale generation. The consistent and even profile of descent after a settled period two minutes from disruption would not suggest this cause given the scale of loss.
d) Unusual variation of interconnection flows from adjacent systems. This option can be readily established from metered sources.
e) Recovery of frequency (governor) response. Expectation to recover in a shorter time scale from frequency stabilisation and prospect of being masked by auto start fast response generation (i.e. pumped storage).
f) Wind excursion. Given the weather conditions on the day (strong blustery winds) this presents by far the most likely explanation. The scale of uncontrolled wind capacity on the system (at least 2.3GW) to give a lull in magnitude as suggested would be entirely feasible, though random. Minor accumulations from some of the above sources could not be entirely discounted. Some indication of wind volatility could be realised with the monitoring of Scottish conditions (if recorded) by extrapolation.

Conclusion.

The uncertainty with critical information surrounding the third drop in frequency prevents any definitive assessment with establishing the basic cause of consumer disconnection. Delayed and inadequate information from DNOs is not helped by a lack of rigour in not exploring the various options to account for this significant failure. Almost two months has elapsed since the incident with a report containing information that could be collected within days. The tone of the report is defensive, describes serious malfunctions of servicing utilities and whose recommendations are entirely focussed on information supply. This circumstance suggests an absence of authority with consequent inability to seek answers.

The knowledge of National Grid to investigate such incidents is unassailable. By a process of elimination it should have been possible to outline scenarios and suggest answers. This is not in the interest of any of the participants. As has been observed, nobody is in charge.

DGB 28th July 2008