TACTICAL AND STRATEGIC SMARTGRID IMPLEMENTATION IN ESB NETWORKS

Teresa FALLON
ESB Networks – Ireland
teresa.fallon@esb.ie

Anthony WALSH
ESB Networks – Ireland
anthony.walsh@esb.ie

ABSTRACT

Neither SmartGrids nor Renewables are ends in themselves, they are merely ***__means to an end__****, this being the achievement of:*

(a) reduced carbon emissions
(b) increased competitiveness
(c) increased fuel security i.e. less reliance on imported fossil fuel

ESB Networks approach to SmartGrids has been targeted at how SmartGrid developments can help achieve the above aims,

A critical part of the approach involves taking into account that technological advances can cannibalize premature investments, but also that lack of investment in new technology will hinder the development and understanding of emerging applications.

'SURFING THE SMARTGRID'

Instead of discussing the application of 'Real Options' to investment decisions in SmartGrid technology, it is perhaps more pertinent to draw an analogy between the introduction of SmartGrids and…surfing.

Surfers want:
- to maximise the amount of time spent travelling in on waves
- to make sure that they don't waste effort by falling off the wave
- not to miss the 'big one' having taken off on the wrong wave.

To get good at surfing time has to be spent out from the shore, studying the incoming waves and assessing whether there is time to run in on a smaller wave, gaining experience whilst waiting for the 'big one'. Also, different surfers are better at certain waves, so the surf group needs to split between waves, each developing expertise so that each can learn from the others' experiences.

Finally, waves come in cycles, so the penalty for missing a particular wave is the delay in waiting for the next similar wave.

So what has this to do with ESB Networks?

The answer is quite a lot, as ESB's approach has been to 'surf the SmartGrid'!

ESBN's first steps were to 'travel out beyond the break' - this meant teaming up with EPRI to look widely at various technologies potentially applicable to meeting ESBN's objectives.

Some of the Technologies are 'big wave' ones such as Smart Meters where practice on 'smaller waves' or technology trials educates the selection and implementation of the right technology.

Others are less critical – paying for their way within the life to the technology itself. They don't tie ESBN into the risk of uneconomic stranded investments, analogous to surfing waves to shore without missing out on any good large waves!

STRATEGIC AND TACTICAL OVERVIEW:

Strategy dictates how an organisation best positions itself to cope with future changes in its environment, so a broadly predictive overview is required of how the environment is expected to change.

Like all predictions such an overview is unlikely to be fully accurate or complete, so the strategy must be flexible to cope with the reasonable degree of uncertainty.

The overview normally presented is that there will be huge change in demand patterns arising from a massive proliferation in renewables and that SmartGrid in the form of ICT enabled networks will be required to ensure that massive grid investment is avoided, with 'smarter' ICT investments substituting traditional network reinforcement. This view is partially correct but needs to be tailored to the particular circumstances in each country.

From ESB Networks point of view:

- SmartGrid is not confined to ICT applications, it includes the application of any new or innovative cost-effective technology

- Ireland has already applications for enough commercial scale windfarms to meet the **Government target of 42% of electricity to come from wind by 2020**, leaving less scope for smaller scale renewables competing. However to fully understand the potential and benefits of micro generation a pilot incentive is justified

- Electrification of residential heating will be required, with fossil heating systems displaced by electrical systems including heatpumps and night storage heating. With large amounts of low carbon renewables, Electricity Carbon Intensity by 2020 will be significantly less than that of fossil fuel heating.

- **Electric Vehicles could have 10% penetration by 2020, as per Government targets**

- The potential for Demand Response will depend on the existence of new electric loads worth switching, i.e. customer based technologies to allow passive demand response or active management of response through aggregation. Legislative changes may accelerate both the electrification of heat and Demand Response.

- Existing Broadband Internet connection availability is currently 88% and increasing – this is a key enabler to the public accessing the benefits of Smart Metering

- International collaboration on research and shared learning is essential ensure that utilities can refine their tailored research programmes and define the roadmap for smart grid without excessive or duplicated research investment.

On the Tactical front the precepts which ESBN must follow are:

➢ Investments in SmartGrid Technologies must be considered in the context that new technologies could 'cannibalize' the benefit of SmartGrid initiatives, so that the costs of such investments must be recovered before such new technologies arrive – otherwise it is better to wait for the new technology and invest in other areas.

➢ Investment decisions must clearly identify each set of product features and costs with their separate benefits. In particular 'By-products' must be clearly identified as such – these are benefits which arise free of additional cost and may be worth using if only application costs are involved.

➢ Flexibility and forward compatibility in technological applications is required so that changes can be accommodated without excessive costs.

➢ The current lifetime of electronic equipment is about 15 years at which point equipment will need to be upgraded on the basis of 'end of life'. This provides a later opportunity for incorporating additional features.

➢ Adoption rates for technologies such as Heat pumps, Electric Vehicles and small scale renewables will generally be dictated by replacement rates of existing technologies, unless large Government grants provide additional incentives. It is not considered likely that these will be available, unless existing pilot projects reveal significant unexpected benefits.

➢ Existing Network Infrastructure will continue to require replacement based on 'end of useful economic life', and on excessive loading. Uprating of existing equipment such as transformers generally allows their redeployment elsewhere on the system so that new capital and maintenance costs are low.

➢ Smart grid initiatives will be tested and designs finalised in demonstration projects in order to formulate a meaningful business case. ESB Networks will focus R&D in a cost effective way through collaboration and shared learning in international R&D projects (EPRI and EU Framework 7 projects) and through Irish based research.

APPLICATION OF ESBN'S STRATEGIC AND TACTICAL PRECEPTS:

Having considered the above, ESBN's SmartGrid program divides into three streams:

– **Stream A**: the adoption and implementation of technologies where the benefits are clear, the risk acceptable and the likelihood of newer technologies cannibalizing the benefits are low

– **Stream B:** The investigation and trial of less clear cut technologies where the potential benefits could be significant but can only be assessed by extensive trials.

– **Stream C:** Technological innovation implemented to support the delivery of Governmental targets

Typical ESBN Stream A Projects

Transmission High Temperature Low Sag (HTLS) Conductor:

The achievement of 42% of electricity from wind generation requires significant reinforcement of the existing transmission grid. Furthermore, much of the existing conductor requires replacement on age grounds regardless. The use of HTLS achieves much of the upratings required at considerably lower costs than traditional methods. Application of ICT could achieve smaller capacity increases at lower initial cost, but any cost benefit is undermined by the eventual physical necessity to uprate conductors on age or load grounds. .

ESBN and EirGrid's policy is now to use GAP HTLS on all Transmission upratings, with the first 80km circuit uprating currently in progress.

Conversion of 10kV Network to 20KV operation,

The best SmartGrid investment ever made by ESBN was the conversion of most of its networks from 10kV to 20kV!

In the late 1990's ESBN's MV networks were old and in need of refurbishment. In addition rising loads had led to capacity constraints and poor voltage. The solution adopted was to convert from an isolated neutral 10kV system to a directly earthed 20kV System, and this work began in 2001.

The benefits achieved in converting to 20kV, for little extra cost to traditional refurbishment of 10kV networks, were:

- doubled MW capacity
- four times the SC level
- half the voltage drop
- 75% less power losses and CO2 emissions

In addition, 20kV Networks can accommodate significantly greater amounts of renewable generation as voltage rise is less of an issue.

Currently 50% of ESBN's network (c.40,000km) has been converted to 20kV and a further 15,000 km is to be converted by 2015, with all overhead MV network operating at 20kV by 2025.

Single Phase Reclosers to supplement Three Phase Reclosers:

Directly earthed systems are prone to earth fault tripping, so extensive automation to avoid continuity problems is associated with 20kV Operation.

Extending comprehensive use of SCADA from every MV outlet, downstream devices such as MV Reclosers are now also SCADA enabled. However, as two thirds of ESBN's MV network is single phase, coordination of protection of Single phase fused spurs (low SC level) is difficult.

Following trials ESBN have begun introducing Single phase vacuum reclosers to replace fuses on long single phase spurs, reducing the risk of such faults tripping the backbone line and providing better protection.

Interestingly, the possible change in the MV 20kV neutral treatment from directly earthed to Arc Suppressed could strand this investment. However these devices are removable and the rate at which ASC coils could be introduced means the benefits will be gained before the end of life of the Single phase Interrupters.

Stream B Projects

Projects with high costs or uncertain benefits, requiring the quantification and qualification of potential benefits via trials,

Wind Projects:

Of the 6000MW of Wind to be connected by 2020, over 50% will be to the Distribution system**. To facilitate achieving this world leading target,** ESB are trialling a number of innovations including:

- **Windfarm Voltage/Var Control Project:** testing the ability to optimally manage a group of windfarms using the voltage/Var Controls of individual windfarms. By looking at a range of operation modes the overall var output of the windfarms can be optimised while remaining within the voltage rise limitations required for coupling with demand customers. If successful, this facility would be a useful control mechanism for TSO's and DSO's.

- **Windfarm Voltage Regulator Control Project**: ESB Networks are testing the use of large 38kV voltage regulators to manage voltage rise on standby for distribution connected wind.

- **Windfarm Distribution Substation Design**
  The nature of Irish distribution windfarm connections varies significantly from demand connections . This is because the clustering of distributed generation is significantly higher and the reliability requirements are less due to windfarm operators insurance arrangements. Hence new distribution substation types, where the predominant requirement is generation, were developed, and the optimum sizing of transformers for such single transformer stations was 31.5MVA 38/MV transformers and 63MVA 110/MV transformers.

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SmartMeters:

SmartMeters are worthwhile if an economic case shows that their overall benefits exceed their cost **at this time. A**s SmartMeters get cheaper and the technology matures their overall costs decrease, but this is at the expense of the possible benefits foregone in the interim. SmartMeters are not a necessity for a SmartGrid although 'by-products' from Smart Metering can be usefully applied.

Confusion between SmartMeters and SmartGrid is widespread and there is a considerable difference to the way in which SmartMeters are expected to operate in Europe as against the US. In the US it appears that control of individual household appliances will be through the SmartMeter itself, with real time communications between the Smart meter and the utility (usually also the electrical retailer).

In contrast, the European trend is for the SmartMeter to communicate once a day with the utility to download time of day data, but to communicate continuously with any Demand Response equipment installed in the customers premise (Energy Box), thus decoupling both systems, enabling flexibility and independence. However this is dependent on a good secondary communication system to the home. As customers in Europe typically have broadband, any requirements for Spot pricing and demand response can then be implemented through the customers own broadband connection. This business model means that the SmartMeter is the facilitator rather than the implementer, and the more sophisticated functionality requirements reside in the customer's own equipment e.g. home automation and Demand Response might come as part of a TV system, as shown in Korea Jebu Island Test Bed.

Accordingly ESBN are carrying out two large scale SmartMeter experiments, each involving about 6,000 customers, the first to assess the communications technologies and types of SmartMeter functionality suitable for Ireland. The second assesses how customers interact with SmartMeters and whether they actually modify their demand when provided with price signals and better data..
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Smart Green Networks:

This programme involves proving existing technologies prior to deployment, and testing the feasibility of new technologies on live MV networks.

- **'Self Healing Network':** Although All MV Reclosers are SCADA enabled, in the event of a storm with large volumes of faults and possible communications interruptions, a system which will restore supply automatically and isolate the fault safely is a major benefit, particularly when the cost of achieving this is very low, simply downloading the appropriate software to reclosers.. The first self healing network ahs already been installed on the Ring of Kerry and several more are in progress.

- **Dynamic Sectionalising:** Using automation devices to minimise losses on feeders through dynamic reconfiguration of network sectionalising points is being trialled, as a low cost high benefit project.

- **Low Loss Amorphous and Hexaform Transformers:** New technologies such as amorphous core and Hexaform (3 phase) will compete with upgrades to traditional silicon steel transformers, driving the price of both down. However successful field trialling of amorphous and hexaform transformers is necessary to be able to specify them appropriately in terms of weight, noise and other features. Accordingly a sample of pole mounted amorphous core and Hexaform transformers are being trialled.

- **Earth Fault Indicators:** Pilot advanced Fault Passage Indicators have been tested and evaluated showing that very accurate fault detection is possible, with communications directly to the operators SmartPhone.. ESB Networks are installing new types of FPI which provide accurate load and voltage monitoring.

Stream C: Projects

Projects to support and prepare for delivery of Governmental targets:

Electric Vehicles:

ESB networks are working with government, international bodies, EU and US, car manufacturers and charging infrastructure manufactures in an effort to drive standards and ensure that this can happen. An initial charging infrastructure roll out plan is now being implemented with the installation by end 2011 of 1,500 public charge points and 2000 home charge facilities for the first purchasers of electric vehicles. Field trials and the development of modelling tools to test the impact of EVs on both Urban and rural LV circuits are underway.

MicroGeneration Pilot Project

To assess the potential and benefits of MicroGeneration, ESB Networks, is offering a pilot feed-in tariff support programme

FUTURE WORK:

The key strategic issue for utilities at present is probably what communications architecture will exist in the future and whether utilities can now make their bet, allowing themselves to structure all future communications requirements and standards for their equipment on this basis. The impact of Smart Metering communication requirements in this environment is likely to be a major factor.

By becoming familiar with the technologies through large scale pilots as well as local field trials ESB Networks expect to be at the right speed to catch the SmartGrid wave and surf ahead!

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