CUTTING THE COSTS OF HV SUBSTATIONS

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ABSTRACT

In this paper the author outlines the approach taken to a complete review of the costs of HV Substations (110kV/MV stations in particular) drawing on his experience when initiating and managing such a project in ESB Networks. The processes required, results obtained and the practical limitations that need to be taken into account are outlined.

BACKGROUND:

ESB Networks is the Asset Owner of the Transmission and Distribution networks within the Republic of Ireland, a small country with an area of some 70,000 sq. km and a population of 4m.

Demand has being growing rapidly – in 1999, the peak demand was 3,436 MW and the customer base was 1.5 million with a load growth of 6% per annum. New customers were being connected at a rate of 50,000 per annum. However by end of 2006 peak demand had increased to 5,042 MW (nearly a 50% increase) and the number of customers connected reached 105,000 per annum – i.e. had more than doubled.

Traditionally new outdoor 110kV Stations were built using Air Insulated Switchgear on sites with a compound size of approx. 63m x 37m (cable connected), with landscaping around the compound, whereas for urban areas Indoor stations with GIS equipment were used.

However load growth forecasts indicated that there would be a significant requirement for extra substation capacity in the period 2006-2010, most of which would involve the building of new 110kV stations driven by new loads.

DRIVERS FOR CHANGE:

At the end of 2005 the electricity regulator (CER, Commission for Energy Regulation) set out the 2006-2010 Price Review, and this included very stringent targets on new capital expenditure, driven by the need to keep Irish electricity costs competitive with those in other European countries.

New HV stations would mainly be 110kV/MV and would tend to be built in areas close to the load centre, unlike older 110/38kV Stations which could be built further away due to the greater 'reach' at 38kV.

Consequently there would be competition for suitable sites with industrial/commercial and even residential developments. The growth in the Irish economy over the past decade has meant that suitable development sites are rare and hence carry a price premium. Furthermore the level of activity within the construction sector has had a significant impact on construction costs

However site and civil works costs are particular to the local economy and hence not as amenable to control as other items such as electrical plant which can be bought by tender on a world market. This means that to save costs in these areas requires station designs with smaller sites and less civil works.

Rapid load growth and customer requirements also meant that new HV substations needed to be built faster. For HV substations in urban areas, which were generally cable connected, site availability and construction times were the main bottlenecks, as circuit connections were usually by non-contentious underground cable routes.

APPROACH:

Project Structure

A Project Board with representatives from the three major stakeholders, ESBI, Network Projects and Networks Asset Management was established in March 2005 with the support of the Director of ESB Networks. A four man Project Team mirroring the Project board structure and headed by a Networks Asset Management representative reported to the Project Board. Terms of reference were to cut overall cost of station, reduce delivery time, improve quality and provide no reduction in required functionality.

Close contact was kept at all stages with ESB National Grid (now a separate entity, Eirgrid) as any proposed changes would have to meet Eirgrid's functional requirements as Transmission System Operator (TSO)

Value Chain

Cutting costs in such a way as to retain value is difficult and requires a sophisticated approach. The method

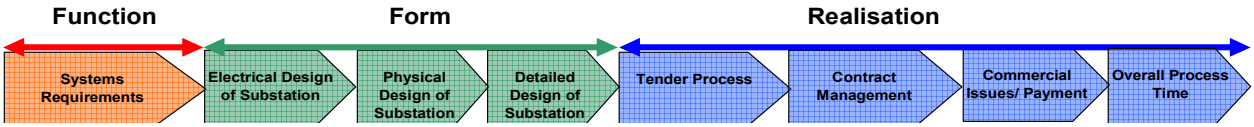

Fig. 1 Value Chain

chosen in ESB Networks was to start with the Value Chain for the HV Substation (Fig. 1) and break down each item in the chain into its cost components, looking at whether the item was required or not and if so was there an alternative method of providing it.

This method provided a convenient structure for organizing the initiatives proposed and ensuring that the overall process rather than any individual part was optimized.

Different members of the Project Team were given responsibility for different parts of the value chain.

Workshop

In order to generate ideas a Workshop of 40 staff concerned with Station Construction was held. Bringing together a large group of people in order to generate ideas can be very difficult and needs to be carefully managed, as there is a significant danger of failure, either through loss of focus or miscommunication.

On the other hand the benefits of a large group of stakeholders contributing to the process include a wealth of practical ideas and 'buy in' from the participants.

Accordingly careful management of the Workshop was required which included:

(a) selection of key individuals from various stakeholder groups such as Substation Designers (ESBI), Substation Builders (ESB Network Projects), Substation Users (ESB Customer Services & Eirgrid) and Substation Owners (ESB Asset Management), and selecting cross organisation groups for each table

(b) using a Workshop theme of 'What's Good about the current process', 'What would be Even Better If..' so that problems could be treated positively as an opportunity for change and so that any defensiveness amongst stakeholders could be avoided

(c) having a tight structure for the Workshop with specific themes for each part of the day, followed by short presentations from each team. Each individual also recorded their own input in a workbook, and the results grouped into a catalogue of over 400 ideas which were later circulated to participants.

(d) Using a professional facilitator as a 'neutral third party' to keep discussions to schedule and set the pace – notably the Workshop started and finished on time!

These results from the Workshop were divided across the Value Chain and the 50 most significant listed for further development.

The generic thrust of the proposals was as follows:

(a) Civil Works and Site size increase costs yet do not increase station electrical capacity – they are just an overhead and should be minimised.

(b) HV stations up to 110kV should be considered as akin to a pad mounted MV/LV transformer, as against a bespoke design. Greater standardisation would result in lower costs and faster turnaround. It would also facilitate the use of 'off the shelf modules' such as containerised control rooms, containerised MV switch rooms etc., which could be used on any new station.

(c) Time on site should be minimised. Minimal civil works on a smaller site would allow electrical fit out to begin earlier. Pre-fabricated modules would fit together in less time and with less time for Design. Commissioning time would be reduced as more of the equipment would have been pre-fabricated and tested off site.

(d) The requirement for future maintenance should be minimised ab initio in the design of the station.

(e) Aesthetics should be improved so that the station blends in better with surrounding buildings. Coupled with a small site this would facilitate the installation of stations closer to the load centre. A 3m high wall instead of a palisade fence with landscaping would be used to further minimise site size.

(f) 'Turn key' contract stations are far more costly, and as ESB has the capability to manage multi-contract construction projects it should capture any available savings itself.

Suppliers

Major suppliers of HV Switchgear were contacted and asked to provide details of how they might achieve savings in cost and time. Product details and applications were provided by suppliers and visits made in conjunction with suppliers to 18 utility substations in 7 countries – France, Germany, Italy, Portugal, UK, Hong Kong and Japan.

Internet searches also provided insights from all over the world, including details with which European suppliers would be unfamiliar.

INFORMATION FROM SUBSTATION VISITS:

Each visit was documented in a 10-12 page report with photographs and circulated to each member of the group.

As an overview from all the visits it was felt that traditional outdoor AIS stations had reached the peak of their development and were not going to further reduce in size. They were generally characterised by a relatively large station compound, complicated civil works and with a large element of on-site fabrication. In some more advanced instances the outdoor equipment could be pre-fabricated on a trailer in the factory so that setup on site was minimised and space and civil requirements reduced and this represented the best of the AIS approach.

The advantages of the AIS were that the switchgear costs themselves were the lowest of all technologies and that it was a well tried and trusted method of station construction. Furthermore replacement of any single item of faulty equipment was straightforward, and in ESB's experience, stations could be designed so that any specific equipment from any existing station could be replaced by a similar piece in another station. This meant that no specialist equipment was needed for repairs, and that ESB was not tied to any particular supplier for replacement parts.

At the opposite end of the spectrum Indoor GIS was the most expensive switchgear used but resulted in the smallest possible size of station and one with the greatest reliability, as every component was under gas. ESB had positive experience over the previous 15 years with using GIS and appreciated that its performance in service was excellent. In fact everything about Indoor GIS is perfect except the cost of the station! Unfortunately high building civil costs plus high GIS costs meant that unless the site was in a city centre this option was generally not feasible.

Consideration was also given, however, to using GIS in buildings which could be produced at lower costs by using steel framed rather than concrete buildings.

Another approach seen was the use of what was termed Mixed Technology Switchgear (MTS), which involved the use of outdoor switchgear made up of either full outdoor GIS with GIS busbar, or GIS modules with Outdoor busbar. The advantage of MTS was that it avoided the civil costs associated with a switchgear building, required a much smaller compound size and required minimal fabrication on site.

Associated with MTS stations was a tendency to use containerised MV switchrooms and Control rooms, and again this reduced civil costs and construction time.

Costs for MTS equipment was higher than for AIS as would be expected, but this was balanced by lower overall Station site and civil construction costs. A further advantage of a smaller site size is that suitable locations closer to the load centre are more readily obtainable and hence the cost of offloading the station via MV network is also minimised.

Comparisons:

Having obtained further useful information and ideas from the site visits the next step was to design and cost each substation type , for both overhead line and underground cable connections.

Each design also had to be technically evaluated to ensure that it provided the required functionality needed by the system operator, and also gave the equivalent performance of the traditional alternative AIS station.

The greatest uncertainty in these comparisons was the cost assumed for the switchgear, as this could only be determined in time through a tendering process.

The outcome of the initial feasibility study was produced in Sept '05 and suggested that a redesigned substation using different switchgear could achieve significant benefits over the traditional AIS station. However the actual switchgear to be used would be determined following a formal tendering process.

IMPLEMENTATION

Pilot Tender

In order to minimise risk and yet avoid any loss of possible savings it was decided that a two stage approach would be used for implementation. In the first stage would be a pilot project involving the next three 'greenfield' HV Stations using a very open, but crude, functional specification to procure the switchgear.

Following this approach allowed the initial cost estimates and hence cost savings to be verified, without exposing the company to any significant financial risk. The benefits of this approach was that no potential savings were lost, yet risk was minimised.

The first tender for three HV stations issued in late December '05 with returns received in March '06. All of the many different switchgear types encountered on the site visit stage were tendered (as well as some others) and the same process of costing each station type carried out.

Examining the switchgear types in detail with their implications on the overall substation costs was very worthwhile, and overall confirmed the results of the initial estimates, namely that MTS Switchgear was the correct choice of switchgear for the HV stations, generally located in urban areas. In these areas the higher cost of the switchgear would be compensated for by reductions in land and civil works costs, as well as by shorter MV offloading circuits. Accordingly MTS (GIS Busbar type) and MTS (Outdoor Busbar Type) were selected.

Fig. 2 MTS (GIS Busbar type)

Detailed design drawings for Planning Permission for two of the most imminent stations were then prepared and it was noted that the local authorities and the developer found the new substation concept attractive, as compound size was much smaller (at minimum approx 32m x 31m for cabled station) and if a wall were used instead of a traditional palisade fence and landscaping, then only a further 2m was needed around the station's periphery for demarcation.

Fig. 3 MTS (Outdoor Busbar type)

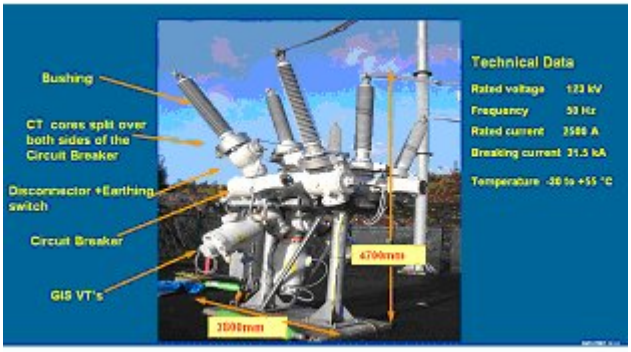

Fig. 4 MTS Station size compared with AIS Station size

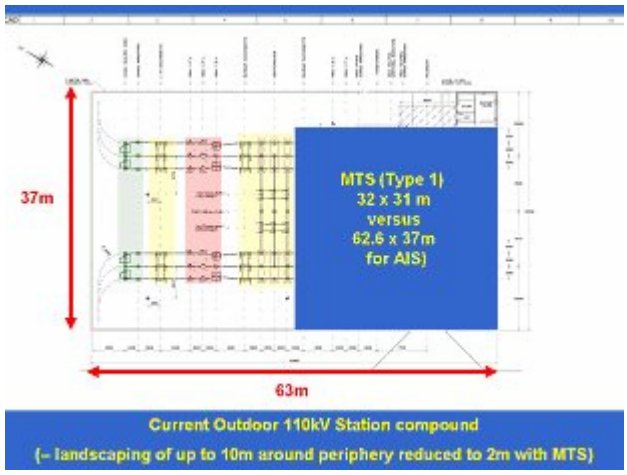

Fig. 5 Elevation of MTS Station Frontage

Main Tender:

Having established that MTS was the correct choice this now meant that the sizes of the substation sites that now had to be acquired for future HV Stations were known, as the difference between station sizes for different forms of MTS is not very significant.

A detailed functional specification for MTS was now drawn up by ESBI, along with a pricing schedule, and checked by Eirgrid to ensure that the switchgear would meet TSO requirements.

This then went to tender for the remaining HV Substations that are required by ESB up to 2010 - currently this tender is under evaluation.

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