Investment Appraisal in a Networks Business

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SUMMARY:

In this paper the author outlines ESB Networks procedures for Investment Appraisal of network reinforcement projects drawing on his experience when Manager, ESB Network Investment (North) outlining the processes required and the practical limitations that need to be taken into account. Background on ESB Networks may be found in the CIRED 2005 paper (no. 269) Business Process Reengineering and Transformation to Asset Management company at ESB Ireland.

BACKGROUND:

ESB Networks is the Asset Owner of the Transmission and Distribution networks within Ireland, a small country with an area of some 70,000 sq. km. The system peak load is relatively low by European standards at about 4,500MW but the overhead Distribution network is similar in size to that in the UK, with 160,000km of OH network, 50% of which is at Medium Voltage (MV) and 50% at Low Voltage (LV) – at MV 60% of the network is Single phase and at LV 90% There are over 180,000 pole transformers with every sq. km having at least one transformer. This extensive network is due to the dispersed nature of the population – overall Ireland has about 12 customers per km versus 27/km in France and 35/km in the UK.

In regard to Distribution HV substations there are 77 110/38kV Stations, 15 110/MV and 490 38kV/MV stations.

With GW growth rates at over 4% pa and a burgeoning number of new connections (50,000 in 1999 rising to 90,000 est. in 2004) the Distribution networks were under severe pressure, having suffered from under-investment in the previous 20 years. In particular the MV network was relatively old and in need of extensive refurbishment, with much of it dating back to the 1950’s or even earlier.

Not alone was the 10kV network in poor physical condition but it was failing to perform adequately on critical measures such as voltage drop, continuity and losses. This gave rise to a requirement to convert those parts of the network with excessive voltage drop to 20kV and to refurbish the remaining 10kV network to a modern standard. Similarly the 38/MV stations and overhead lines also required attention. In particular the 38kV station population included a comparatively large number of stations built by Siemens in 1927, which were now congested with extra switchgear and control systems (but with inadequate clearances for 41kV). Not alone did these stations represent a serious continuity risk (and possibly some potential safety issues), but along with many other 38kV stations, they had high load levels, generally over 90%. The particular problem faced here was that those stations which were most heavily loaded were generally in the same geographic area, yet were required to provided standby to each other. Other stations that were less heavily loaded could however be in adjoining towns 40km away, and could only provide limited standby. Even with ESB’s aggressive standby criteria of 160% of normal load on a daily basis during standby, the security of supply available was at breaking point.

Following the 2001 Regulatory Price Review a program of Network Investment was developed to address these issues, with substantial expenditure allocated.

STRATEGIC ALLOCATION OF INVESTMENT FUNDS:

The initial phase of investment selection was simple and straightforward, as the projects tackled were glaringly obvious and had been overdue for some years.

The next tranche of investments for selection was however more complicated as there were a much larger number of
candidates, all of which deserved attention, yet only a limited amount of money available.

This meant that a fundamental and radical review of the traditional Network Investment procedures within ESB Networks was required in order that returns on investment could be optimised. This was critical due to the volume of expenditure required and the pressure on the network due to high growth rates, averaging 4% pa, plus the accelerating investment in the 20kV conversion and refurbishment of the MV network.

This was approached on two levels – Strategic and Tactical. At a Strategic level the overview was that there was a fixed and limited amount of money to be spent and that this expenditure should provide the optimum benefit to customers. Over expenditure in any area would therefore produce sub-optimal expenditure in the remaining areas.

The next question was how to allocate the funds available between different expenditure categories, and to this end some consultancy work was undertaken with EA Technology.

Optimal allocation of funds over a suite of candidate programs in order to maximise value to the business is a complicated process, particularly when it may be difficult to put a specific monetary value on the Business Driver affected, or to quantify the risk associated with each expenditure class. It is even more difficult when decisions on Capex have knock on impacts on resulting Opex.

The first step was to formally agree what aspects of business values would be driven by the expenditure and how these would be measured – typical aspects were Safety, Continuity, Cost Saving, Capacity increase, Voltage regulation, Customer Service Perception etc, with Capacity measured in MVA, Continuity in CML’s saved, Cost Savings in Euros etc.

Following this, separate candidate programs were identified and the impact of these programs on the Business values assessed, along with the implementation costs; e.g. cable fault indicators would have a low cost, a high expected saving on CML’s (because cables are normally heavily loaded and in city areas with many customers) and high impact on Customer Service Perception (because customers would appreciate fast restoration of supply) but have no impact on any other Business values.

These would then have to be compared with alternative candidate programs such as the refurbishment and uprating of old substations, where Costs would be high, Capacity increase high, Continuity risk improved, but impact on remaining values low.

The approach taken was to use some multi-criteria decision making software (called Equity), coupled with a decision conference attended by senior managers within Networks. The way in which this works is that different candidate expenditure programs are identified and the impact and cost of these programs is assessed against several criteria. The senior managers then compare one program against another using their subjective judgement and experience, coupled with what hard data has been incorporated to produce a relative ranking of the candidate programs. The list produced can then be sorted according to what programs give the best ‘bang for your buck’ and if the budget available needs to be cut back those programs that are least cost effective are cut back first, until the target expenditure is reached. If certain levels of minimal expenditure are required under all circumstance e.g. to meet legal requirements, then this portion is identified as a separate program and isolated as non-optional; typically new and increased customer connections would fall into this category.

Obviously the context of the decision conference is one where a Long Term Strategy for the development of the network is in place (e.g. new voltage levels being considered etc.) and where the overall impact of Risk Register content on the Corporate Balanced Scorecard is included.

In order to facilitate the contribution network investment in maintenance and refurbishment would have on business values, a risk rating was assigned to each asset class based on the probability of failure and it’s impact on business drivers (such as Continuity, Safety etc.) – this also facilitates cross weightings and ranking.

An example of the output is given in Fig 3 where each of the candidate programs are listed by voltage class. The contribution of each program relative to it’s cost is shown graphically in the inset diagrams. Thus in the silo MVS/S (Medium Voltage Sub Stations) it is seen that program 1 (minimum essential expenditure) and program 2 (replacement of faulty Transformer Ring Main Units) overlap and are both essential. Program 3 covers the cable fault indicators already discussed, which have low costs but a significant impact on continuity, and Program 4 is planned maintenance which is seen to provide a better return than urban automation (e.g. because continuity is good in urban areas due to standby from alternative circuits.
but long term faults from failure of equipment due to lack of planned maintenance would affect the individual substation and customer connected).

Essentially the ‘science’ would seem to give a more exact and correct answer than is actually possible, but what it does help achieve is a process by which the relative ranking between different programs can be agreed by the different Asset Managers in a manner that is consistent and logical – although it may still not be optimal.

**INVESTMENT PROCESS:**

Having decided the amounts of money that are best spent in different areas the next requirement is to ensure that the individual projects that arise in these areas are worthwhile and definitely required in the current regulatory period.

In order to tackle this issue the experience in the UK was explored, with advice taken from UK utilities such as YEDL.

Previously overall budgets for capital projects had been set at Head Office level and then allocated to Regions in proportion to the Region’s stated requirements for investment. However this could be sub-optimal in that it could result in a relatively even spread of funds on a geographic basis whereas what might be required was a concentration of funds in only certain areas.

The fact that ESB had now moved to an Asset Management Structure, with large amounts of contractors meant that limited resources in any geographic area were no longer a barrier to extra expenditure – resources could simply be moved temporarily to the area required.

Decisions on all asset expenditure, Maintenance, Load-Driven new works, System Improvement and OPEX were now made centrally on a national basis by Asset Management, with all synergies available from the combined approach taken into account.

This is best illustrated in Fig. 4 which is the IDEF Process Map for any proposed expenditure.

**Fig. 4 IDEF Process Map covering Network Investment**
The first process in the map above is ‘Assess Work against Business Values’ and this covers the initial review of the proposal in the associated Investment Appraisal report. The proposal must take into account the overall context in which network planning in the area has been progressed, as ‘Network Change Plans’ are seen as an input, but must also be within parameters set by ‘Regulatory requirements’ and ‘Asset Strategy Policies’ as well as being within budget ‘Financial Approval Limits’. It is costed approximately on the basis of typical standard costs.

The output Investment Appraisal is then reviewed by other Asset Owners to assess what synergies may be possible e.g. maintenance on a transformer may be brought forward to coincide with an outage required for the installation of new switchgear. A consolidated Investment Appraisal report is then produced and the Business Case made for the Capital Approval required – this involves a detailed, accurate costing so that the financial approval which is provided is accurate and against which the success of the project can be judged. If the more detailed costing results in costs significantly in excess of those in the original Investment Appraisal the project is referred back for re-evaluation.

Obviously the manner in which the Investment Appraisal is prepared (process 2.2.4.1) is very important in order to achieve the optimal selection and prioritisation of projects.

Accordingly an Investment Appraisal process similar to that YEDL used was applied, whereby each project was evaluated against its impact on identified business drivers, so that the optimum selection could then be made.

Whilst this process had worked well for YEDL and other
of capacity. Typically growth rates in the UK are low and the Network capacity available is high due to the ‘brownfield’ nature of new developments. This meant that in the UK the Investment Appraisal was quite finely tuned with the decision to proceed or defer being discretionary and made on the basis of a cost/benefit analysis and the availability of funding.

However on the ESB Networks the situation was quite different – growth rates were rapid and network capacity was near its limit. Large, new point-loads for new industries were arising which distorted any plan based on long gradual and predictable load increases. Furthermore the amount of investment required and justified by ESB’s planning criteria exceeded the amount of funds available.

In turn this meant that the key components of an Investment Appraisal were:

(a) what was the risk to customer service of not carrying out the investment now and how did this compare with alternative investments?

(b) given the rapidly changing circumstances (e.g. new loads) how flexible was the investment to provide step changes in capacity and, in contrast, how likely was it to be stranded if a large new load required an alternative supply.

If stranded, how much of the investment could be recovered?

In order to answer (a) a new ‘in house’ program (Fig. 5) was personally developed by the Network Assets Manager which tracked the Scope of each proposed project, it’s Technical Approval, and justification via an Investment Appraisal. This provided a nationwide list of all capital projects by program type, and also had some information on the construction status of each project, although actual expenditure however was held in a different system. (SAP). This program also covered all planned maintenance so that unnecessary overlaps on maintenance or refurbishment caused by the impact of new works could be eliminated. This program thus facilitated the implementation of the process shown in Fig. 4.

THE ‘PATH OF LEAST REGRET’:

In looking at competing alternatives NPV is used but is sometimes insufficient as each alternative not only has a sequence of cash flows but also an associated sequence of options along the investment path at which different choices can be made. However valuing ‘real options’ is difficult, but one technique used is ‘the path of least regret’ whereby the NPV of the project if abandoned at each stage is calculated. This allows a measure of the risk and flexibility between different options to be assessed.

This also means that the physical structure of the investment required may need to be examined and optimised in order to obtain the flexibility required, although this may mean paying an extra cost for this safeguard. A typical example would be where network reinforcement could be provided by either a new cable or an increase in transformer capacity at a somewhat higher cost. If everything were certain then the new cable might be the cheaper option, but given uncertainty the cable could become a stranded asset, whereas most of the investment in the substation uprating would be recoverable. If the cash flows of the two investments are laid out on a yearly basis and then the NPV of the cumulative investment to that year is matched against the NPV of the cumulative investment recoverable if the project were scrapped in that year, it is possible to find the ‘path of least regret’.

Similarly simply changing the timing of certain parts of the project can significantly reduce the risk and minimise sunk costs e.g. providing MV network associated with a new station as extra reinforcement to the existing network, and then deferring the building of the station itself until the load is more firmly established. There is an extra cost in this approach, the time difference between the two investments may be small, but if there is uncertainty then it avoids excessive sunk costs.

Another strategy is to develop stations that can utilise existing available network capacity but then be converted at low cost to stations capable of providing much greater capacity e.g. a station convertible from 2x10MVA at 38/MV to 2x20MVA at 110/MV. The benefit of this is that the existing capacity in the 38kV network can be fully used until the load has developed sufficiently, at which point the station can be converted without an outage to a 110/MV station. The extra initial cost involved is small and is effectively an insurance premium against the load developing significantly – effectively it is a staged implementation of a 110/MV station with a high amount of recoverable material.

RISKS:
The use of the Investment Appraisal approach also encourages a more balanced approach to risk, in that it is explicitly recognised and specific mitigation strategies identified. This removes some of the unnecessary conservatism and caution which has traditionally been associated with utility planning, as, not alone has the risk been confronted, it has also been matched against the benefits from taking on this risk. This means that there is a more balanced view taken on investment planning, as it can be recognised that whilst some will go wrong, on balance, the extra benefits will more than outweigh such cases.

Investment Appraisals traditionally examine options and select the best option based on the criteria used. In practice the use of the Investment Appraisal has also sparked off fundamental reviews of traditional options which can lead to a choice of more economic options being available for review: One example of this would be the inclusion of the future option of High Temperature Conductor being available for use on the Distribution system for future upgrades if required, the discounting of this non-traditional option for network uprating in the future if required favouring less expensive initial investments now.

THE UNGLAMOUROUS SIDE:

There is also another side to planning a network and this is the painstaking and routine calculations associated with the large scale conversion and refurbishment of ESB’s MV network (approx 77,000 km). Obviously there is a huge amount of expenditure involved and it has to be spent appropriately – unfortunately the only way in which to evaluate where to allocate expenditure is by simple toil!

Accordingly rough criteria were first developed to assess which parts of the MV network needed to be converted to 20V and which could simply be refurbished. These criteria were: if the application of 3 boosters in series on standby, coupled with the loads expected in 2008, caused more than 10% voltage drop, or if the conductor was overloaded, then 20kV conversion was required (¬ ESB networks can have single MV outlets of up to nearly 200km of single and three phase conductor). Accordingly every MV outlet in Ireland (2,200) was individually examined to assess its need for conversion.

This gave the necessary indication of the scope of work involved and its likely cost. Following this, each outlet for 20kV conversion was examined individually and in detail to list what single phase network would be converted to three phase, where boosters would be installed, what network automation would be required, what conductor would be used, where reconductoring was required, and what modifications to the network should be associated with the conversion in order to maximise the benefit of this program to the customer.

Following this exercise the broad parameters of the network conversion and refurbished were known, and detailed costing sheets were then prepared by Patrollers for issue to the Contractors – up to 1,800 contracting staff from 20 different countries, converting and refurbishing up to 16,000km of MV network pa!

APPLICATION OF THE PROCESS:

In the Distribution business of ESB about €2.2b is to be spent by 2005 at which stage it is expected that the following will have been achieved:

- 32 new 110kV Substations,
- 24 new 38kV Substations
- 30 38kV Substations refurbished
- Refurbishment/20kV conversion of 60,000km of MV network
- Connection of large numbers of new customers – 90,000 customers are expected to be connected in 2004, from 50,000 in 2000.

Similarly on the Transmission side about €1.4b will have been spent by 2005 on new EHV substations and upgraded Transmission lines.

FUTURE:

Substantial investment in ESB Networks is still required. We have had some success with the existing process and are now working on improving it further, so that we get the’ LOUDEST bang for our buck’. 