REPLACEMENT OF THE AGEING ASSET BASE – THE CHALLENGE TO REGULATORS

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ABSTRACT

For a mature electricity transmission or distribution network the expenditure required to replace ageing assets may represent typically half of the capital expenditure budget and exhibit a rising trend. The resources of a regulator to perform a budgetary review are however limited in comparison with those available to the network operator to prepare the budget. The paper discusses review techniques used and experience gained over a number of regulatory reviews of capital expenditure of both distribution and transmission networks.

INTRODUCTION

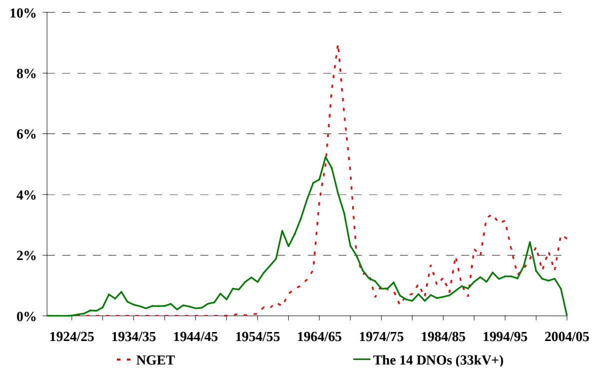
Whilst the management of ageing transmission and distribution assets is receiving the increasing attention of network operators, the setting of the level of revenue allowed for funding the continued operation and/or replacement of assets is generally the responsibility of the regulator acting in the interests of the customer. Most network assets are generally held to have average lives of about 40 to 60 years, or longer for some cable types.

A regulatory price control review is generally conducted every four to five years. As part that process, and to ensure that an appropriate and sustainable level of network performance is achieved at an efficient level of cost, three tests of the efficiency of proposed investment may be applied by a regulator:

- justifiable need
- efficient design and life-cycle cost and
- appropriate timing.

Management of network assets encompasses consideration of asset performance, reliability, safety and the meeting of increasingly stringent environmental and local government planning requirements. The amount of information required by the regulator to enable informed decision making is increasing as new techniques are introduced, notably those concerned with assessment of asset condition and remaining life for an entire asset population. However the resources available to a regulator, mainly data, manpower and time, are limited and there is also asymmetry of information and resources between a network operator and a regulator. The regulator therefore needs to be able to model the required level of asset replacement without recourse to a detailed and time-consuming analysis of the asset base.

Figure 1 – Comparison of transmission and distribution asset values by age in Great Britain



The asset age situation in Great Britain is illustrated in Figure 1 by comparing the proportions of existing transmission (National Grid) and (primary, 33kV+) distribution network operators' (DNOs') asset bases by year of installation. Installation activity reached a peak in the mid 1960s, some 40 years ago, and the network operators are presently forecasting rapidly rising replacement quantities and expenditures. On its own, Figure 1 may be regarded as evidence of age, but not need for replacement.

REVIEW OF REPLACEMENT OF ASSETS

Drivers for replacement

The principal drivers for replacement of assets include:

- condition (reliability, failure, obsolescence,)
- environmental (oil filled apparatus, overhead lines)
- safety (poorly performing switchgear; line fittings)
- asset performance (increased functionality)
- operating costs (repair and maintenance, losses)

Programme preparation by network operator

A network operator would be expected to maintain a comprehensive database of network assets, including their many and varied characteristics and functions as well as details of condition (reported and updated at appropriate intervals), performance, repair and maintenance history. From such a database an assessment of expected remaining lives of the assets, including identification of replacement candidates, would be made as a key input to the planning and prioritization process of preparing a programme and budget for the replacement of the assets.

The network operator should also be able to undertake a separate high-level review of the replacement volumes and expenditures as well as strategic scenario analysis over the medium to longer term.

Review by regulator

Asset replacement model

In Great Britain for the last two distribution price control reviews (DPCR3 undertaken in 1999 and DPCR4 in 2004) and transmission price control reviews (TPCRs in 1999/2000 and 2006 (TPCR2006)) undertaken by the energy regulator, Ofgem, a retirement profile model has been used where the retirement profile reflects the probability of retirement at a given age for all life-related reasons (e.g. condition, reliability, failure, maintainability, obsolescence and safety) [1]. The model considers asset age profiles, unit costs of asset categories and uses asset age as a proxy for condition, based on lives attained. The outputs of the model are the replacement quantities and expenditures by asset category and by year. The model also has facilities for undertaking scenario analysis by examining sensitivity of the modelled output to variation in technical asset lives and further provides a global strategic view of the risk to be assessed in terms of percentage weighted average remaining life of an asset category. Although the model considers like-for-like replacement, the level of "betterment" due to, say, replacement with increased capacity or undergrounding can be reviewed through consideration of cost differentials.

Replacement or refurbishment

Replacement, also termed as renewal in some jurisdictions, is the complete replacement of an asset with a new modern asset and generally considered on a one-for-one basis for review purposes. Refurbishment is the partial replacement of an asset to restore it to its original state. Typical examples of refurbishment concern overhead lines where, for example, supports may be retained but conductors and/or fittings replaced – ideally these components should be modelled separately as was done for transmission lines in TPCR2006. There is an increasing practice of the undertaking of cyclic refurbishment of wood pole overhead distribution lines on a (typically 12-year) cycle basis with the replacement/refurbishment of defective components and therefore of only a part of the lines concerned.

Asset lives

Table 1 presents technical asset lives for replacement planning purposes as published in three sources. In general these lives should be longer than those used for depreciation and valuation purposes. Where a retirement profile is adopted, a normal distribution profile may be assumed for simplicity. As data allows, the retirement profile should reflect the actual retirement history, for example where end-of-life failures may occur independently of age.

Table 1 – Comparison of technical asset lives

	CIGRE WG 37-27 [2]		Victoria, Australia, EDPR 2001 [3]		Ofgem DPCR4, 2004 (GB) [4]	
ASSET	Mean life	σ_d	Mean life	Min life	Mean life	σ_d
TRANSFORMERS						
110kV or >	42	8			55	11
Other transformers			53	50	58	11
11 kV Pole Mounted			43 to 49	40	56	10
SWITCHGEAR						
110kV or >	38 to 43	6			49	10
HV & MV indoor			54	45	53	7
HV & MV outdoor			52	45	46	8
MV air break			45	45		
LV indoor			50	50		
LV outdoor			30	30	56	11
OVERHEAD LINES						
110kV or > overhead lines					66	9
- towers	63	21				
- conductors	54	14				
Other overhead lines					45	11
- supports (wood)	44	4	38 to 59	35 to 53		
- supports (concrete)			63	60		
- conductors			60	60		
CABLES						
110kV or >	51	20			61	9
33 kV (paper)			70	70	76	10
11 kV (paper)			70	68	85	12
11 kV (XLPE)			37	35		
LV Paper			70	60	103	13
LV non-paper			44	40	103	13
Services 1 phase			73	70	100	10
Services 3 phase			73	70	100	10

Trends in asset lives

The average lives of most of the principal British distribution assets show an increasing trend as presented in Figures 2 and 3 and illustrate that the modelling of replacement of assets is dependent on assessments of asset lives that are extending as condition assessment techniques improve. The standard deviations have also shown an increasing trend, typically from about 8 to 11 years.

Similar developments in the assessment of the technical asset lives of transmission plant and equipment have been reported by National Grid in Great Britain, recognizing that as knowledge has increased, lives have been extended for the majority of assets [5].

Figure 2 – Trends in average lives of substation assets

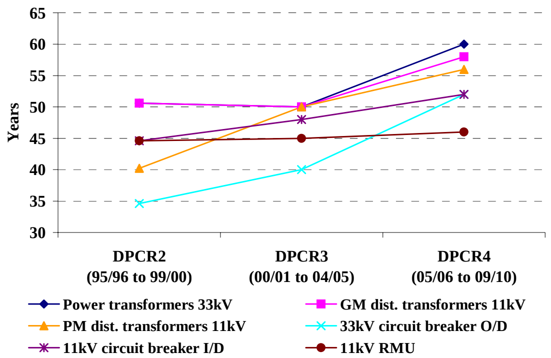
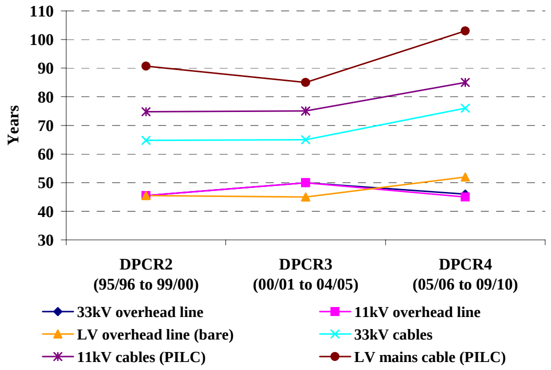


Figure 3 – Trends in average lives of lines and cables

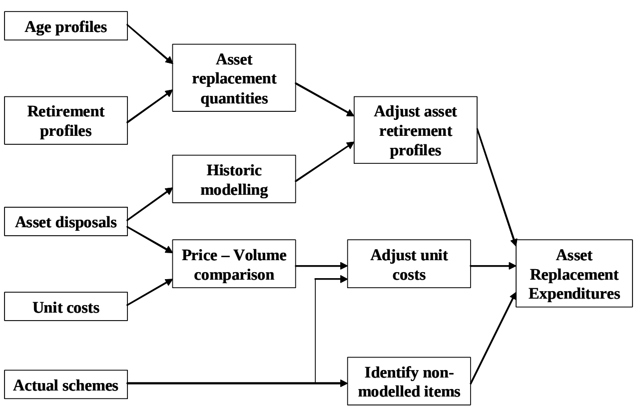


Verification of asset lives

Ideally a network operator should record the ages of assets as they are removed from the network and the reason for such removal (e.g. capacity, condition, safety, environmental, obsolescence, diversions). Records of end-of-life failures in service or deterioration mechanisms that limit life are also used to indicate the initial upturn of the retirement profile. For primary distribution (HV) and transmission networks the operators generally adopt a policy of replace before failure on account of the potential widespread consequences of such failure. On secondary distribution networks (MV, LV) some assets may be allowed to run until they fail.

For asset replacement modelling purposes in DPCR4, weighted average retirement profiles were derived from the corresponding asset population age profiles and the individual retirement profiles as declared by each of the fourteen British DNOs. For TPCR2006, the opportunity was taken to model the historic asset replacement quantities, using the age profiles as at the start of the historic period (2000/01 to 2004/5) and the asset lives (retirement profiles) as declared by the transmission network operators. In a number of cases where the modelled quantities exceeded the actual replacements, the asset lives were extended to reflect those actually being attained and were then applied to the modelling of the asset replacement quantities for the forecast period. This process resulted in a decrease in the modelled quantities. The unit costs of plant and equipment as declared by the network operators were also compared with the actual costs through a simple price-volume comparison or by a comparison of typical historic scheme costs. [6] Figure 4 presents the general methodology used.

Figure 4 – Adjustments to asset retirement profiles and unit costs – TPCR2006



Regulation in an environment of increasing investment

Where price control regulation applies, network operators are generally incentivised to retain such efficiency savings as they may make. There may therefore be a tendency for network operators to submit high forecasts at a price control review. Accordingly in DPCR4 Ofgem introduced a "sliding scale incentive mechanism" whereby those DNOs whose forecasts were close to Ofgem's allowance would receive a higher reward for efficiency savings (and conversely a higher penalty for overspending) than those DNOs whose forecasts appreciably exceeded Ofgem's allowance. [7]

Increases in excess of 100 per cent in overall capital expenditure were allowed in TPCR2006 and accordingly Ofgem introduced a "safety net mechanism" whereby, if a transmission company's investment was to fall by more than 20 per cent below its allowance in any year, this fall would trigger an automatic review of its capital expenditure.

Operators' forecasts and regulatory allowances

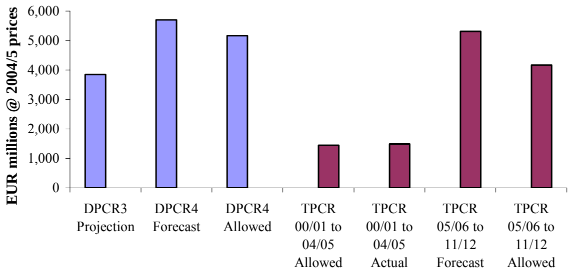
Figure 5 presents comparisons of the respective projected, forecast and allowed expenditures for the recent British distribution and transmission price control reviews:

- DPCR3 (2000/1 to 2004/5) and DPCR4 (2005/6 to 2009/10) – asset replacement expenditures and
- TPCR (2000/1 to 2004/5) allowed and actual non-load related (largely asset replacement) expenditures and

- TPCR2006 (2005/6 to 2011/12) forecast and allowed non-load related expenditures. [8]

The allowed distribution expenditure represents an increase of some 34 per cent over the annual average expenditure of the historic period. However the increase in allowed transmission expenditure represents a virtual doubling of that expenditure on an annual basis, largely due to increases in refurbishment of overhead lines and replacement of switchgear and cables.

Figure 5 – Comparison of operators' forecasts and regulatory allowances



Regulatory reporting

Two of the most experienced regulators, the Essential Services Commission of Victoria, Australia, and Ofgem in Great Britain have accordingly introduced annual regulatory reporting requirements for distribution network operators to supplement the price control reviews at four to five-year intervals. These reporting requirements allow the variances between actual and forecast expenditures to be monitored steadily and so improve the review process. Ofgem is also intending to introduce annual regulatory reporting for transmission network operators in Great Britain in 2007.

Risk

Risk assessment methods, including criticality analysis, are used by network operators and are an important part of the detailed and complex process of prioritizing asset replacement. Following the Asset Risk Management survey of DNOs carried out in Great Britain in 2002, Ofgem has encouraged the network operators to undertake voluntary certification to BSI-PAS 55, Asset Management [9].

A regulator will however also need an overall output metric of asset risk to complement the input-related modelling of asset replacement and output-related annual reporting of network reliability performance. The concept of weighted average remaining life of assets has been used elsewhere to obtain a general view of the appropriateness of asset replacement expenditure levels and may be considered as an indirect indication of asset risk (Table 2). Caution should however be exercised in comparing the weighted remaining lives from different jurisdictions as asset lives may differ.

Table 2 – Asset risk: weighted average remaining life (WARL)

Organisation	WARL (%)	Comment
London Underground, Great Britain	50	Ultimate reversionary requirement
AGL, Victoria, Australia	50 to 40	Forecast: distribution assets over 20 years
Transpower, New Zealand (NZ)	44	Ratio of depreciated to replacement cost of ac assets (33 to 220kV)
Ministry of Economic Development, NZ	>50	Distribution networks – condition reasonable

CONCLUSIONS

A regulator requires a means to model asset replacement as is provided by retirement profile-based modelling which is also useful aid to a network operator for reviewing a programme built up from detailed considerations principally of asset condition. There is a general trend to date for asset lives to increase. The integrity of the modelling process remains dependent on quality of data and, to this end, the retrospective modelling of historic replacement enables verification of asset lives. Weighted average remaining life provides an overall output metric of asset risk.

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