KEMA Consulting

Life Cycle Costing

Qualification document - Rev 3

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04 April 2009

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Revision History

Rev.	Date	Description	Author	Checker	Approver
0	13/01/05	Initial Draft	KJO	MT	
1	27/01/05	MW Revision of Initial Draft	KJO	MW	MH
2	09/11/06	KvO Revision	KJO	PKo	VWo
3	07/04/09	KvO Revision	KvO		

1. Introduction to Life Cycle Costing

The main economic principle for assessing the economic value of any assets is that their value to investors be equal to the net present value of the expected future cash flows generated by those assets.

The practical difficulty in making this assessment for regulated monopoly businesses is that the future revenue derived from the assets is itself determined by the regulator; hence the issue of circularity associated with the use of discounted future cash streams as a methodology to value sunk assets. This potential circularity could be eliminated by the use of a replacement cost approach. The value of a network is the sum of the depreciated replacement cost of the assets that would be used if the system were notionally reconfigured so as to minimise the forward looking costs of service delivery.

Life Cycle Costing applies the generic logic of the replacement cost approach and extend this through dynamic consideration of the total assets related costs over the life span of the assets. Life Cycle Costing is a process of economic analysis to assess the Life Cycle Cost of a product or a project over its life cycle or a portion thereof. Life Cycle Cost (LCC) analysis and Total Cost of Ownership evaluations are the basis for decision making for the wide range of different industries, including the power industry. A main objective of LCC analysis is to quantify the total cost of ownership of a product or a project throughout its full life cycle, which includes research and development, construction, operation and maintenance, and disposal. Life Cycle Costing is a concept used for making decisions between alternative options, optimising design, scheduling maintenance and revamping project planning.

LCC analysis is an economic evaluation technique, which is well suited to compare alternative designs with different cost expenditures over the project life. All relevant costs or whole-life costs (often referred to as through-life costs) should be converted to their equivalent present value (it is not only about the initial investment and acquisition costs, but all cost occurred over the anticipated life cycle must be considered).

The option identified with the lowest total present value is the most economical or least cost option/approach. The whole-life costs of a project are the costs of acquiring (including consultancy, design and construction costs, and equipment), the costs of operating and the costs of maintaining over a whole life of a project through to its disposal. These cost include internal resources and departmental overheads, where relevant; they also include risk allowances as required; flexibility (predicted alterations for known change in business requirements, for example), refurbishment costs and the cost relating to sustainability and health and safety aspects.

2. KEMA's vision on Life Cycle Costing

LCC is a valuable and straightforward method of tracing cost consequences of various alternative investment projects with long life spans. It is especially suited for use in the power industry, because the design life of electro technical projects is generally very long (over 20 years).

LCC analysis should be performed early in the design process while there is still a chance to refine the design to ensure a reduction in life-cycle costs. LCC can be applied to any capital investment decision in which relatively higher initial costs are traded for reduced future cost obligations. It is particularly suitable for the evaluation of installation or system design alternatives that satisfy a required level of installation or system performance but may have different initial investment cost, different operating and maintenance and repair costs, and possibly different live-time expectancies.

It is our opinion that LCC analysis provides a significant better assessment of the long term cost effectiveness of a project than the alternative economic methods that focus only on first cost (initial investment) or on operating costs in the short-run.

Moreover, LCC is fundamental for the regulation of network companies. The inclusion of asset costs in the revenue requirement formula recognises the owner's investment in the regulated utility and the capital-intensive nature of network infrastructure businesses. Failure to include adequate capital related costs, as part of the revenue requirement of the regulated business, risks a reduction in investment in the industry. This could ultimately lead to reductions in cost coverage and quality service levels; hence to a reduction of security of supply in medium and long term. Fundamental to the measurement of capital costs in the revenue requirement is an assessment of the regulated business' capital investment and the establishment of the regulatory asset base (asset value that is used for the calculation of return on assets).

LCC analysis can be applied for:

- Selection, evaluation and comparison of alternative designs
- Selection, evaluation and comparison of replacement options, life extension or disposal of aging parts of infrastructures or equipment
- Identification of cost effective improvements
- Assessment of economic viability or products and projects
- Evaluation and comparison of alternative strategies (e.g. maintenance, replacement of components etc)

- Establishment of regulatory asset base for regulatory purposes including pricing and price control

3. Why hire KEMA for Life Cycle Costing?

KEMA is a global player and has been involved in technical consultancy and business consultancy in Europe, North and South America, Australia and Asia. KEMA has advised more than 500 clients in over 70 countries, including utilities, regulators and policy makers. In the electricity industry, KEMA has particular experience of providing economic and technical advice in business, regulation and policy making areas both an overall and a detailed level. The company's consultants have a unique expertise combining economic and technical knowledge as well as deep understanding of complex nature of power business.

We believe that KEMA is uniquely qualified to conduct LCC analysis:

- **Independency and impartiality:** KEMA has no vested interest in any equipment and software tools. We provide impartial and objective consulting assistance with integrity
- **Planning experience:** active involvement in transmission and distribution planning from the earliest conceptual analysis and ranking of alternatives for a wide range of clients
- **Costing and budgeting experience:** KEMA has an extensive cost database with entries derived from:
    - Subsequent calculations of major low, medium and high voltage infrastructure projects in various countries all over the world
    - Equipment offers and proposals of (leading) manufacturers for all relevant civil, mechanical and electro technical components in high voltage transmission lines, substations (indoor / outdoor, air insulated / gas insulated), cable connections
- **Extensive technical network and asset experience:**
    - Experience in condition scans and assessments of electrical equipment and entire networks;
    - Design experience in the fields of special high voltage installations, substation and transmission line projects; and

- Operation and maintenance experience. Our project teams have real-life experience in planning and budgeting processes within utilities.

- **Extensive expertise in network regulation:** KEMA has supported regulators in different countries over the world on different issues such as development of incentive based regulation systems like price-cap and revenue-cap controls, quality monitoring systems, quality standards and incentive schemes, pricing network access and ancillary services, establishment of revenue requirements, cost allocation rules and tariff setting for functional segments in power industry, auctioning interconnection capacities, benchmarking and lowering network costs, writing and reviewing grid and system codes etc. Hence KEMA is familiar with the interaction of LCC analysis and asset issues with overarching Price Control considerations.

- **Responsiveness:** we always work with and for our clients in order to maximise product value. We constantly fine-tune approaches, convey preliminary results and match these results with customer needs and expectations.

The vast majority of evaluation techniques require a number of assumptions to be made. It is a challenge to make unbiased assumptions, which produce fair economical comparisons of alternate designs. For power industry related projects one of the key assumptions for LCC analysis, that has to be made, is the lifespan expectations of components or systems. KEMA is in a unique position to deal with the aspect lifespan. We have gained broad theoretical as well as practical expertise in a great number of projects. Furthermore LCC analysis requires fair and well-founded cost calculations of the whole-life costs. KEMA has an extensive cost database, has carried out cost calculation projects and LCC projects for different utilities in various countries.

4. KEMA's Proprietary Life Cycle Costing tool

KEMA has developed a Life Cycle Costing tool which is well suited to support the decision making process considering alternative designs and solutions for electrical infrastructure topics. The Life Cycle Costing tool can be used in the earliest stage of a project (e.g. feasibility study) as well as in the design phase of a project.

KEMA's experience in electrical infrastructure related LCC projects is that, in most cases the costs of the initial investment (upfront costs) are significant compared to all other costs that occur during the lifespan of the system or equipment. We integrated these experiences in our Life Cycle Costing tool and laid the emphasis on the initial investments. We have also included the lifespan of the system or equipment and the associated costs that occur during the lifespan of the system or equipment. Where, the initial investment cost of two alternative

designs are close to each other the expected lifespan or the prognosis of the other cost (cost during the lifetime) can make the difference.

Following are the key functionalities of KEMA's basic Life Cycle Costing tool. This tool can be easily adapted to clients' specific needs.

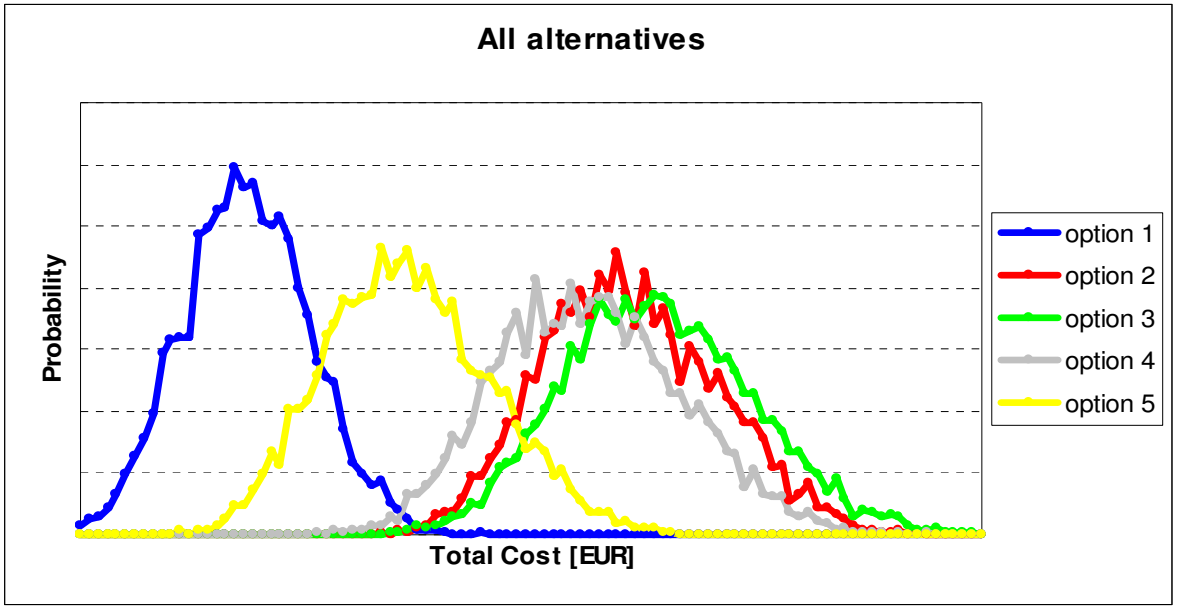
- General
    - Two up to five alternative designs can be compared in one calculation run.
- Module for initial investments (investments at T_0), where:
    - A distinction can be made between labour and material cost.
    - Per record (one record contains one cost driver for example: "building overhead line towers") the following information can be filled in: cost driver description; unit amount / quantity (nominal, minimum and maximum value); cost per unit (nominal, minimum and maximum value).
    - The tool allows surcharges in terms of percentages on labor and material costs, which can be useful especially in the feasibility phases of projects.
- Module for costs (maintenance and operating costs, cost of losses) that occur during the anticipated lifespan of the project, where:
    - Per record (a record contains one cost driver for example: "painting overhead line towers") the following information can be filled in: cost driver description; costs (nominal, minimal and maximum value); interval at which the costs occur; percentage that the costs increase over the years.
    - The records are automatically linked to their project.
- Module Net Present Value
    - Two discount rates can be filled in to simulate the effects of the discount rate on the outcome of the LCC calculations. The discount rate represents the value of money over time. The discount rate is used to convert costs occurring at different times to equivalent costs at a common point in time (Net Present Value calculation).
- Module Monte Carlo Simulation
    - Especially within the feasibility phases of projects, not all cost drivers can be specified or calculated with the same accuracy. The Monte Carlo Simulation

varies all values between their limits (minimum, maximum value). Primary attention is given to the variation of the initial investment cost:

- Variation of quantities between their upper and lower limits
- Variation of unit costs between upper and lower limits.

The results of the LCC calculations are presented in graphs and tables. An example of typical results are for the LCC analysis of a asset replacement project are shown below.

Graph 01 shows the results of a LCC analysis for a replacement project where five design alternatives have been analysed; the graph presents the probability versus the Net Present Value of the total costs, which is the outcome of the Monte Carlo Simulation.



Graph 01 – example output: probability versus NPV of total cost in EUR of a major replacement project

In Table 01 the nominal values of calculations are shown.

CONCLUSION					
Criteria / *Title*	A option 1	B option 2	C option 3	D option 4	E option 5
Lifespan in years	50	40	40	40	40
INITIAL INVESTMENT [EUR]	*50.000.000*	*60.000.000*	*65.000.000*	*55.000.000*	*60.000.000*
TOTAL COST [EUR]	*118.000.000*	*100.000.000*	*52.000.000*	*115.000.000*	*90.000.000*
discount rate					
Net Present Value (1) 10%					
Standard calculation including residual value	*61.000.000*	*66.000.000*	*67.000.000*	*64.000.000*	*63.000.000*
discount rate					
Net Present Value (2) 12%					
Standard calculation including residual value	*59.000.000*	*65.000.000*	*66.000.000*	*62.000.000*	*62.000.000*

Table 01 – example output: nominal values (simulation)

Hence, using the information provided by the graphical and tabular output of the LCC analysis, a decision can be made on which is the most economical design option – in this case Option 1.

5. Some key LCC team biographies

KEMA's staff members are our greatest assets. Our leading industry experts provide invaluable practical experience and innovative solutions, tailored to meet our clients' diverse needs.

Upon request we can provide the (detailed) resumes of our LCC team members.

6. Summaries of recent project references

KEMA is in an excellent position to carry out LCC analysis and LCC related projects. Our track record shows LCC projects as well as project related to the major aspects within LCC analysis, for example: lifespan expectation of electrical equipment and parts of electrical infrastructures, cost calculations and estimates for electrical components/assets, valuations of electrical infrastructure and technical Due Diligence investigations.

Upon request we can provide examples of our track record.

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