LIFE CYCLE COST (LCC) IN NORWAY – EXPERIENCE AND STATE OF ART

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Abstract

In 1978 the Association of Consulting Engineers (RIF) put "Annual Costs" on the agenda. Since that Multiconsult has been active part in developing methodology, models and tools. During this period we have gained a lot of experiences, which are important for further development of LCC-topics.
During this period there has been some milestones in our work. Among the most important are the Norwegian Standard NS 3454 "Life Cycle Costs for Building and Civil Work, Principles and Classification" (1988, revised in 2000), three books "Annual Costs – Calculation Guides (1993 and a special paragraph about LCC in the revised law of Public Procurement.
Book 1, in the series of "Annual Costs – Calculation Guide", is the actual textbook of LCC and gives information and guidance on the use of LCC-calculations during the process of planning, design, construction and use. Calculations are performed at three different levels depending on the purpose.
To keep the building industry updated and to implement new experience a series of new publications within the field of "Facility Management and Life Cycle Planning" are published. In the LCC-field we got "LCC-Calculation Guide" (2003) and "Decomposition and Depreciation of Building Components" (2005). A revised law public procurement (2001) requires LCC considerations in the planning phase.
At this stage some computer-aided tools are available in Scandinavia. In many cases there are tailor-made programs for one project. These are usually used as prototypes for other projects. Directorate for Public Construction and Property (Statsbygg) developed the program LCProfot. This is now used in connection with most of the public projects.
There are also established some LCC-network. A couple of these are dealing with KPI (Key Performance Indicators) and perform seminars 4-6 times a year. A Nordic baseline project, called "LCC for buildings", (www.lcc-bygg.com) was carried out during the period 1999-2001 with the goal of mapping the current status on methods and use of LCC in the individual countries. Through this project it has become evident that the Nordic countries have a relatively similar view, methods and goals about the use of LCC – calculations. The outcome of the project is a common platform / model for costs specification of LCC.
Experiences, together with increasing interest in Facility Management, indicates the focus ahead will be on LCC-calculations in early stage, Life Cycle Planning as a common topic, including demands on adaptability, and LCC and the buildings influence on core business economy.

Keywords: **LCC, classification and standardisation,network and tools**

INTRODUCTION

It has been a goal to implement Life Cycle Costing (LCC) in construction projects in Norway. This has lead to several good results, however LCC – calculations has not yet been achieved as an integrated part because there has been too little focus on how the results can be imple-mented to all the activities of the sector including the ordering role of the project manager.
Through the revised law about public procurements in Norway (June 2001), it is now required to implement LCC – calculations in the planning stage of all construction projects in the public sector, so there is a movement in right direction.
A few methods and tools are available to perform these calculations. Focus is now increasing through a growing number of organisations and networks regarding LCC.
The Nordic countries have a relatively similar view of using LCC – calculations, which is to illuminate the consequence of an investment and different investment alternatives as well as using experiences from the period of use when carrying out new projects. In the period 2002-2004 this has been a collaborating R & D project between the Nordic countries.

SOME HISTORY

The Norwegian ”King Magnus the Lawmaker” introduced what we could call the first law of maintenance by defining who is responsible, maintenance frequencies, and at what time of year. He wrote in 1280:
”Every farmer belonging to the church must tar the church every third winter".
The intention was of course to perform preventive maintenance so the building should have as long life as possible. They knew that wood is vulnerable and therefore took precautions to maximise the lifetime, as we can see in fig 1.

- High quality building components
- Detailed design for durability
- Skilled workmanship
- Knowledge of environmental impact
- Preventive maintenance

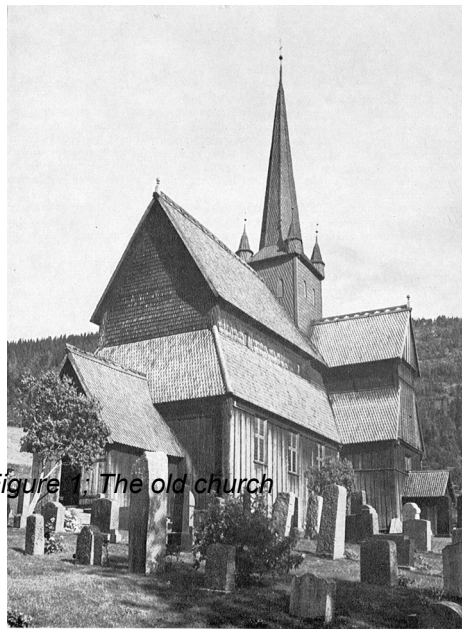


Figure 1. The old church

After the law from 1280, LCC was not put on the agenda until 1978. From that year and up to day, there has been several highlights in the development of LCC understanding and use. The most important are:

- 1978: "Association of consulting engineers RIF" put Annual Costs on the agenda ("Annual costs" being the name used in connection with LCC in Norway).
- 1982-85: RIF assembling cost data through
- 1987: RIF made "Annual costs – calculation guide".
- 1988: Norwegian Standard NS 3454 "Annual costs for buildings" published by "The Norwegian Standards Association
- 1993: 3 books on "Annual costs – calculation guide" based on the guide from 1988
- 2000: Revised NS 3454 "Life Cycle Costs for Building and Civil Engineering Work, Principles and Classification".

The standard (NS 3454) is now an important tool in connection with LCC work.

NORWEGIAN STANDARD 3454 "LIFE CYCLE COSTS FOR BUILDING AND CIVIL WORK – PRINCIPLES AND CLASSIFICATION"

NS 3454 clarifies the relationship between Life Cycle Costs, Annual expenses, Lifetime costs and Annual Costs and prescribes an economical chart of accounts for these costs. The most important definitions in the standard are:

- Annual Expenses: What you have every year. Can differ from year to year
- Life Cycle Costs: Investment + annual costs + residual costs (demolition)
- Lifetime Costs: Net present value of LCC
- Annual Costs: Annuity of lifetime costs

Annual expenses includes costs for Management, Operation, Maintenance, Development and Service (MOMDS) throughout the period of use, and are calculated as a fixed yearly amount, which includes capital costs and costs for MOMDS as well as costs when the period of use is ended (demolition). The annual costs are calculated as an annuity which means same amount every year (fig. 2). The main rule is that all costs must be in the value of the year of calculation. A building will be used for it's purpose for a certain time. First it is investment cost or capital cost. During the period of use there is a stabile management-, operation- and maintenance cost as well as periodic costs throughout the life of the building such as replacements of building elements and large redevelopment and upgrading projects. Such costs come with different intervals, maybe just once during the lifetime of the building. To make these costs homogeneous and compatible, they all have to be discounted to the same time – level. In Norway we use a present value calculation. Input to this calculation will be:

- Cost and intervals of action
- Real rate of return
- Lifetime of buildiNG

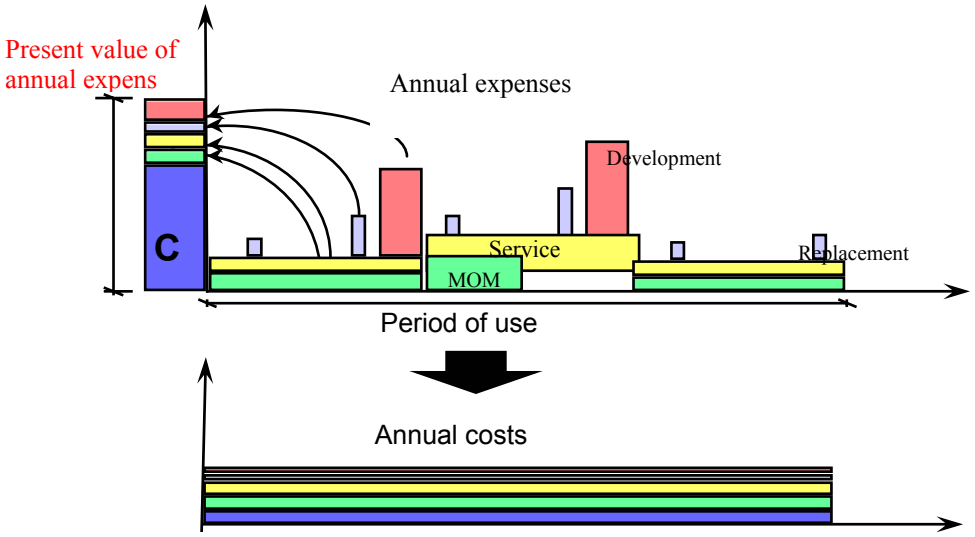


Figure 2: Annual cost model (Ref: T. Thorsnes, Statsbygg)

To be able to compare these costs with other accounts, other projects/buildings and use the data in benchmarking it is convenient to evenly distribute the present value amount over the lifetime of the building, so that we get an annual amount. This is the amount that have to be set aside every

year during the whole lifetime of the building in order to cover all the costs of constructing, using and the profit/cost of selling/demolishing.
The rate of interest used in the calculations will have a considerable effect on the result.

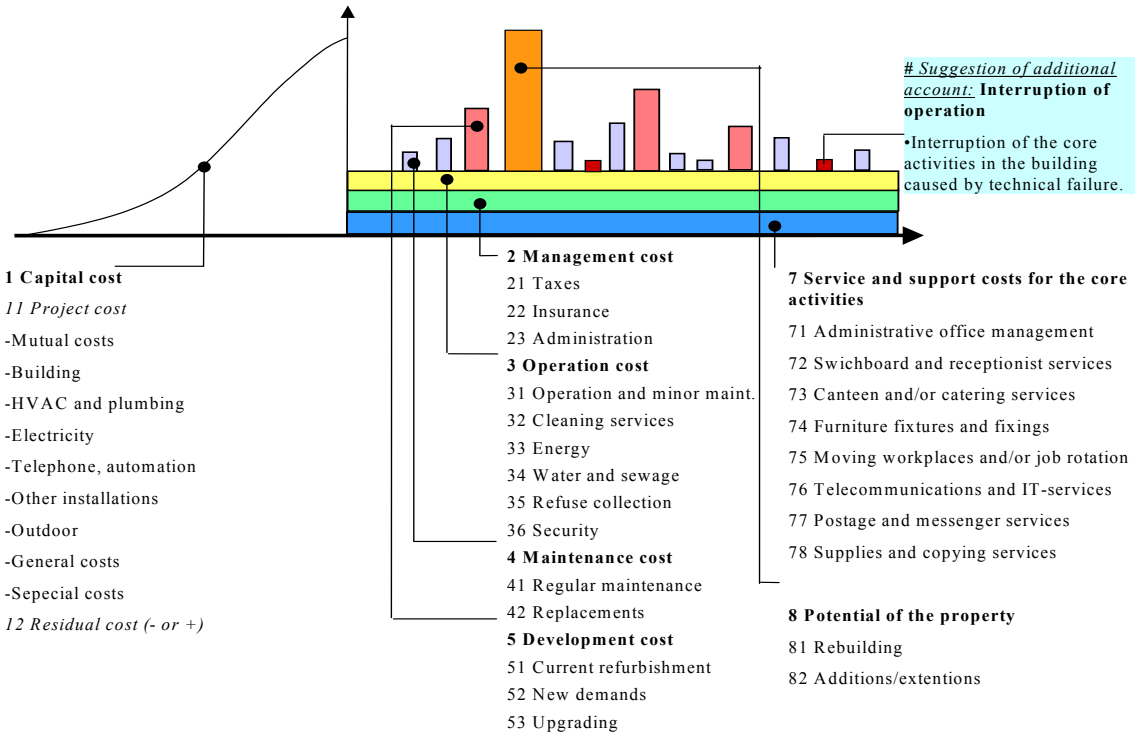


Figure 3: Classification of costs connected with annual cost model (Ref.: S. Bjørberg, Multiconsult)

At the beginning only 4 accounts where introduced; Capital-, Management-, Operation- and Maintenance cost. Generally, everybody involved has taken for granted that the use of buildings have been regarded as static. In the 1990-ies we experienced that this was far from the case. New requirements started to accelerate which indicated that there was a need for an "account" for development of the building to accommodate new requirements both by the authorities and by the users. The planning of a new state hospital in Oslo showed through a survey of the accounts at the old hospital, that more than NOK 300 pr m2 was used annually for maintenance, but, in reality, not much maintenance was carried out. The money went to changes in layout and infrastructure as a consequence of new medical equipment, routines etc.
A development account was added along with accounts for service costs (costs associated with activities supporting the core business) and potential of the property (large development projects that change the functions). Fig 3 and 4 shows the chart of accounts from NS 3454. Table 1 contains an explanation of what each cost account includes.

	STANDARD CATEGORIES					ADDITIONAL CATEGORIES		
	REAL ESTATE AND PROPERTY							
	FM – Facilities							
	MOMD							
Capital-cost	2 Management cost	3 Operating cost	4 Maintenance cost	5 Development cost	6 Unused	7 Servicing and/or support costs for the core activities	8 Potential of the property	9 Unused
10 Unused)	20 (Unused)	30 (Unused)	40 (Unused)	50 (Unused)	60 (Unused)	70 (Unused)	80 (Unused)	90 (Unused)
11 Project cost	21 Taxes	31 Daily	41 Scheduled maintenance	51 Current	61	71 Administrative office	81 Rebuilding	91
12 Residual cost	22 Insurance	32 Cleaning	42 Replacements	52 Official rules requirements	62	72 Switchboard and services	82 Additions / extensions	92
13	23 Administration	33 Energy	43	53 Upgrading	63	73 Canteen and/or catering	83	93
14	24	34 Water and	44	54	64	74 Furniture, fixtures and	84	94
15	25	35 Waste disposal	45	55	65	75 Moving workplaces and/or rotation	85	95
16	26	36 Watchguards security	46	56	66	76 Telecommunications and services	86	96
17	27	37 Outdoor	47 Outdoor	57 Outdoor	67	77 Postal and messenger	87 Outdoor	97
18	28	38	48	58	68	78 Supplies and copying	88	98
19 Miscellaneous	29 Miscellaneous	39 Miscellaneous	49 Miscellaneous	59 Miscellaneous	69	79 Miscellaneous	89 Miscellaneous	99

Figure 4: Chart of accounts (NS 3454)

Account	***Description***
2. Management costs	
21 Taxes	Property tax, other fixed fees to public authorities.
22 Insurance	Mutual building insurance
23 Administration	Accounting, making routines, budgets, external aid, etc.
3. Operation cost	
31 Operation and minor maintenance	Janitor, operational personnel, material, small tools, oiling, adjustments, service agreements, unexpected damages etc.
32 Cleaning services	Wages incl social expenses, material, daily- and main cleaning and window
33 Energy	All energy, also outside.
34 Water and sewage	Water usage, sewer, water purification.
35 Refuse collection	Operaton of renovation system in the building, collecting, disposal, etc.
36 Security	Access system, security guard, etc.
37 Outdoor	Showeling snow, sweeping, gardening-work, etc.
4. Maintenance costs	
41 Regular maintenance	Maintenance caused by normal wear and tear (f. eks painting) and is done on regular basis to prevent decay.
42 Replacements	Replacement of building components and technical installations That have a shorter service life period than the building itself.
47 Outdoor	Maintenance of roads, lots and green areas including installations. Replacement of trees/plants is also included here.
5. Development costs	
	Running reconstruction/upgrading caused by new requirements from: the core business (reorganising, new equipment etc.), local authorities that makes upgrading from original standard necessary and from users new demands

Table 1: Explanation of accounts

ANNUAL COST BOOK

There are three books in this series "Book 1, Annual Costs – Calculation Guide", "Book 2, Annual Costs - Buildings in use", "Book 3, Annual Costs - Calculation Examples".
Book 1, however is the actual textbook of LCC. The main purpose of this book is to give information and guidance on the use of LCC – calculations during the process of planning, design and construction of new buildings and renovation projects. Such calculations may be used as decision basis for choosing between alternative projects or solutions.
The book begins with explaining the principles of LCC – calculations including the required basis of data and information to perform them. Then it goes into explaining in detail how different calculations can be carried out and also discusses possibilities of influencing the whole life economy of the building. Tables suggesting measures of maintenance and intervals of action on different building elements are enclosed in the last section of the book.
LCC – calculations are commonly performed at three different levels. The levels are suited for different purposes with the calculations.

Level 1 *(Calculations at this level are suitable at the initial planning stage of a project.)*
Gives a rough estimate on life cycle cost and annual cost for the project. The result can be used as input in investment analysis.
The analysis will further more be used as an indication signal in the project planning phase about what ambitions there are for the project, and be a basis for further economical management.
To carry out a level 1 LCC – analysis the following basis is necessary:

- Location
- Type of building and area
- Calculation rate and expected service life (calculation periode)

Because of limited information about the building, calculations on this level are done on the basis of rough figures based on experience. The following formula can be used.

$$\text{Annual cost} = (\text{Project cost} \times \frac{rate}{1-(1+rate)^{-time}}) + \textit{Annual cost of MOMD}$$

Level 2 *(Calculations at this level are suitable at the programme/planning phase)*
On this level the focus is to find project solutions that lay within the frames that was set under the preliminary phase of the project. Final determination of cost frame should be done on sketch project calculations.
To carry out a level 2 LCC – analysis the following basis is necessary:

- Location
- Type of building, sketches and areas
- Construction programme with specified technical standard and main systems
- Calculation rate and service life (calculation periode)

Calculation on this level is normally based on key-figures on two-figures level according to NS 3454 account plan.

Level 3 *(Calculations at this level are suitable at the pilot project/main project phase)*
The purpose of calculations at this level is to control the estimates of earlier phases, as well as discover and assess alternative solutions to improve the total economy of the project on short or long term. During the project phase considerable savings can be achieved through putting a great deal of thought and often modest investments into the planning. If the result is a well planned and well solved project the need for extra investments on a later stage will be reduced. A systematic,

operation oriented design process is the most important tool to produce buildings with sound whole life economy.
To carry out a level 3 LCC – analysis the following basis is necessary:

- Structure, materials and installations must principally be decided
- Quantities for the different parts of the building must be measurable as a basis for calculations.
- Relatively certain price-information must be available.
- Calculation rate and service life must be decided
- Intervals for periodic maintenance/replacements must be presumed.
- Size of operational staff and management must be presumed
- Calculation of energy - budget.

The principle of this type of calculation is to estimate intervals for maintenance activities and replacement of building elements as well as costs for each activity. By using the net present value method, all these costs payable at different stages in the lifetime of the building, is transferred into a single amount in today's value.
It is important to remember that to obtain the lowest possible life cycle cost is not the goal in itself, but it is a goal to tell the consequences of the investment.
To obtain a good whole life economy at an early stage at the project, it is necessary to focus on the most dominating cost elements.
Capital cost is influenced by area/shape of building, type of construction, type of materials and choice of technical installations. They always have to be seen in connection with operation- and maintenance costs planning for future reconstructions, additional area and new technical installations.

- *Operation and minor maintenance cost:* Quality materials/technical installations and easy access to components is essential factors influencing the cost.
- *Cleaning services:* Surfaces/materials that provides easy cleaning. Floor space with limited disruption of walls, columns and interior. Entrance area arranged for walking off dirt on the way in.
- *Energy cost:* Several measures can be done in order to reduce energy usage and hence energy cost. Different sources of energy must be considered. Design of façades and windows will play a major role in how much energy that will be let in and out.

NEW PUBLICATIONS SERIES: "FACILITY MANAGEMENT AND LIFE CYCLE PLANNING"

New knowledge about LCC has been developed and building practises have changed. Buildings of today have much more technical installations than 10-15 years ago. Focus on flexibility and adaptability in buildings is also increased.
A new publication that builds on the "LCC- calculation guide" was published in 2003. It is one of several publications in the series "Facility Management and Life Cycle Planning". The new publications include updates from the annual cost books as well as a lot of changes, additions and new subjects. Issues such as intervals of maintenance activities, decomposition and depreciation of building components, adaptability in buildings, principles of establishing rent and public procurements are examples of what these publications encompasses.
One of the issues that is treated in the LCC – publication, and is a subject of current interest, is the distinction between capital cost and maintenance cost. According to today's principles of accounting the building is depreciated as a whole, including technical installations. By decomposition of building elements and a separated depreciation, some of the replacement costs will be activated in the capital balance. The capital cost will be higher and the maintenance cost

lower. Costs related to item no 53 in the NS 3454 (fig 3) will also be activated, and reduce the costs associated with operation.
The principles of the proposed accounting practice are illustrated in figure 5 and 6.

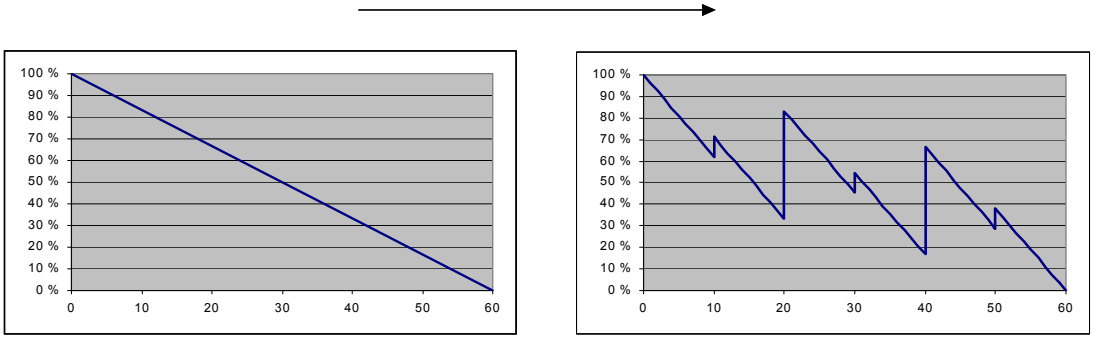


Fig 5: From traditional to decomposed depreciation – gives increased rate of depreciation. (Ref: A. Larsen, Multiconsult)

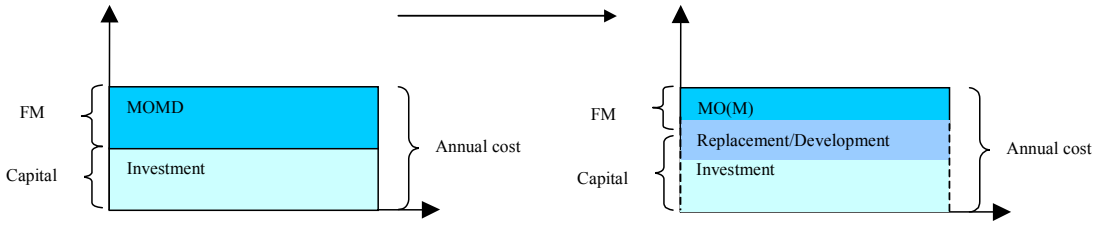


Fig 6: Activating replacements involves "moving " parts of the maintenance- and development costs from operation to capital. (Ref: A. Larsen, Multiconsult)

A publication of this issue was published in 2005 and it shows the differences in depreciation rates on different service life periods and different types of buildings (hospital, school and office block).

Detailed LCC – calculations (level 3) involves estimating intervals for planned maintenance and replacement activities. Every activity occurring with a certain interval is given a cost and then the present value of this cost is calculated on the basis of how many times this activity will occur during the service life of the building.
Appraisal of service life of building elements and the cost of replacement is important, and will have a great influence on the result of the calculations.
Tables included in the new publication as well as "Book 1, Annual Costs – Calculation Guide" and the "Building Detail Pamphlet" from "Norwegian Building Research Institute" describes maintenance activities for different building elements and gives intervals for when these activities usually should/must be carried out. (table 2 shows an example of this table).

NS 3451	Component	Material/ construction	Maintenance	Description of maintenance	Intervals of maintenance (years)		
					Short	Medium	Long
266	Gutters/ downpipes	Gutters/ downpipes plastic	replacement	Remove old gutters and downpipes. Mounting new ones. Includes flashings and hooks	20	25	30
		Gutters/ downpipes metal, painted	painting	Cleaning gutters. Scrape downpipes, gutters and flashings. Scrape rust, treat whith rust preventive paint. One coat of paint on downpipes, gutters and flashings	5	10	15
		Gutters/ downpipes zink or plastic coated steel	replacement	Remove old gutters and downpipes. Mounting new ones. Includes flashings and hooks	25	30	35
		Gutters/ downpipes copper	replacement	Remove old gutters and downpipes. Mounting new ones. Includes flashings and hooks	30	40	50

Table 2 Examples of intervals and activities (Ref: NBI, Norwegian Building Research Institute)

Extensive knowledge about these activities is essential in order to achieve good life cycle planning. These tables are currently the subject of discussion and revision.
It is difficult to estimate the intervals of replacement and maintenance. Especially for technical installations the replacement cost constitute a large percent of the total LCC – cost. Not only the technical service life of building elements decides when it will be replaced. New demands from users, reconstruction projects, technical development, etc. are factors that can contribute to shorten the service life.
Another important aspect concerning the replacement cost of technical installations is how much of the installation that really is replaced on average. Often a replacement cost of 100% of the initial investment cost is used in LCC calculations. Maybe 60% or 80% is a more correct figure.

PUBLIC PROCUREMENTS, §6

Norwegian law of public procurements was revised 1st. July 2001. The new § 6 says that:
"Life Cycle Costs and environmental consequences of the procurement must be considered when making the requirements"
How to interpret the requirement in regard to life cycle costing, and thereby how the requirement shall be answered, has later been discussed among people in the building industry and a guideline is under development.
All the work LCC – work within the built environment have been related to buildings. However, the requirements of the law are general, and therefore we have to broaden the perspective to also include civil engineering projects of different kinds.
In September 1998 "The Directorate of Public Construction and Property" (Statsbygg), already set demands in their contracts to the project managers that they, in addition to calculation of the project cost, also have to calculate the MOM – cost.

COMPUTER AIDED CALCULATION TOOLS

At this stage there are some computer-aided LCC calculation tools available in Scandinavia. In many cases however, using self – made tools/programs, that is tailored for one project in particular, might be just as good as needed for the calculation.

LCProfit

One program, "LCProfit", developed by "The Directorate of Public Construction and Property" (Statsbygg), is used in large scale because they introduced compulsory LCC – calculations on all their projects in the pre-project phase. Their way of calculating the lease builds on the annual cost model explained earlier, which means that capital costs and yearly MOMD – costs are transformed into a common comparable form and makes the total annual rent that the tenant pays. The LCC analysis must be approved before the decision about the detailed project is made. The intention is that the LCC analysis shall be a natural part of the design process, and that general key figures must not be used uncritically.
It is not required that "LCProfit" is used in the calculations but it must be carried out in accordance with NS 3454, and presented in a certain way.
The program is a spreadsheet model developed in Excel. It contains 11 sheets with different purposes: Front page, prerequisites, calculations, management, operation, maintenance, (Building, HVAC and electrical work), alternatives and factors. The program can be downloaded from www.lcprofit.com.
Information on intervals and costs of operation and maintenance for the building elements, (normally a mix between level 2 and 3), the calculation can be executed.
To be able to compare the costs, which occur at different stages in the service life of the building, it is necessary agree upon the anticipated service life of the building and a calculation rate that reflects the anticipated inflation and return on capital.

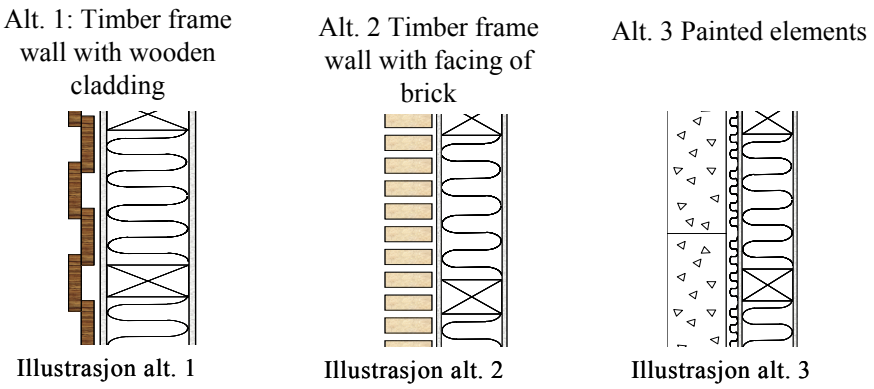
Key Figure Tools

Collection of key figures is important in order to benchmark and discover potential of improvement.
Later in this report the most comprehensive key figure database for MOMDS – data in Norway will be presented. This database belongs to the KPI Benchmarking Network.
Energy and cleaning services is two of the most cost demanding accounts in the balance sheets of a facility manager. Consequently tools and key figures for estimation of these costs are rapidly developing. The concept behind most tools calculating energy costs in buildings is supplying the program with information about building type, sources of energy, technical installations and price/kwh.

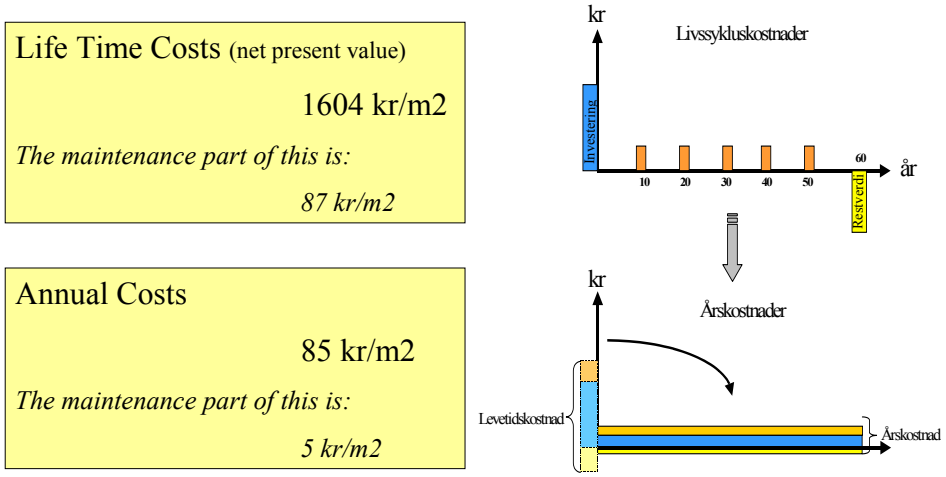
Excel

LCC calculations can be performed in several ways and at several levels. It is important that the tool used is suitable for the stage the project is in. "LCProfit" for example, is too comprehensive for calculations at an early stage, simply because the information available is not detailed enough to make this tool practical. Sometimes detailed quantities and prices are available for some disciplines and not for others, which makes it necessary to do a calculation that combines detailed information and key figures. Excel can be used to develop your own calculation program that is specific for a certain project and practical for the stage the project is in and the information available. Formulas used in detailed calculations are rather complex and a spreadsheet - based program is almost necessary to carry them out.
An example on use of excel is a LCC-program for calculation of LCC for alternative wall materials and solutions. This program can be seen on www.byggutengrenser.no ("Livsløpskalulator"). For each alternative you get a proposal on life time, interval for

maintenance together with some key-words on what the influence factors are on the given data. Then you can determine what data you think is the right ones for your alternatives. You also have to choose service life, e.g. the period of time you want to do the calculation. If the service life and life time is different, the program calculate rest value of the component. Figures 7 and 8 gives an example on the use of the program.



Figur 7: Example of LCC evaluation for three different types of external walls.



Figur 8: Example of LCC evaluation for onet typs of external wall.

LCC NETWORKS

As LCC are becoming a more important part of the built environment and the interest is growing, networks are established to discuss, benchmark and compare procedures and data. As the subject is relatively new, there are probably a fair bit of uncertainty about what LCC involves and how to do it. The establishment of networks working with different aspects of LCC is a growing trend. Establishing and joining networks is a way to compare practices and performance, developing new methods and share and coordinate existing methods. This chapter present the KPI Benchmarking network (nfb) in particular and talks about other networks that are relevant to Norwegian LCC – work.

KPI Benchmarking Network (nfn)

The network nfb or directly translated "key figures for benchmarking" is a Norwegian association for all kinds of organisations and persons involved with, or interested in Facility Management. Members are mostly large property managers both public and private and some consultants. It is a non-profit organisation with focus on the activities that can contribute to a more effective exploitation of resources within the FM environment. Key figures is an important management tool related to operation and utilization of buildings

The network evolves around an internet- based database for collecting economic and technical information about buildings. All types of buildings can be registered in the database. A wide spectre will only improve its utilitarian value and many objects within each building-type improve the statistical foundation, so it is an ambition to get as many members and objects as possible. For the time being the database contains data from a majority of schools, nursing homes, hospitals, offices and industrial buildings.

The database is an internet based solution open for all members and protected with password. The website also offers pages with general information about the network, which is available to everyone (www.nfb.no).

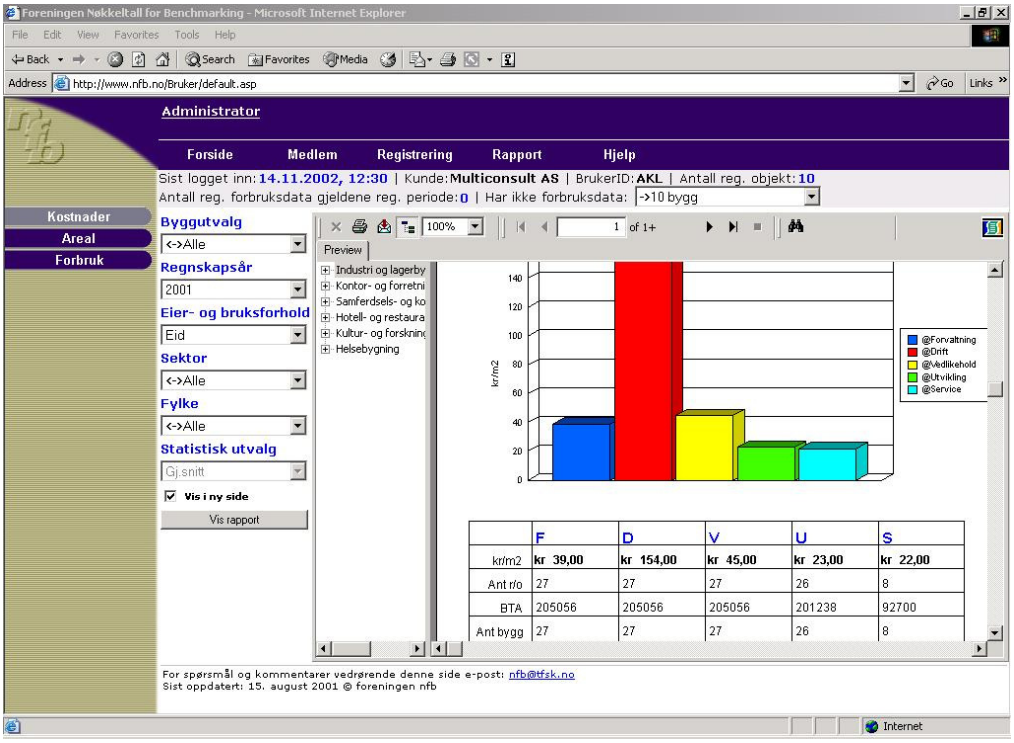


Figure 9: Screen picture of report generator on nfb's web page.

The data to be filled in are devided into three main categories:

- *Member data:* Name of organisation, Address and contact details, Employees in the FM department, Private/Public sector, Line of business, Percentage of building area that is owned, rented or let out, Etc.
- *Object data:* This is where the more or less static information about the buildings shall be filled in, which means information about the object/building that usually don't change such as: Building type, Identification, Address, Name of building, Location, Area, Year of construction, Etc.
- *Consumption data:* Management costs, Operational costs, Maintenance costs, Development costs, Consumption of water, Energy usage, etc.

In September 2005 there will be a new and more interactive version of the program. Users can put in their own figures and then define reports in accordance to their needs.

Nordic LCC-project

A Nordic baseline project, called "LCC for buildings", (www.lcc-bygg.com) was carried out during the period 1999-2001 with the goal of mapping the current status on methods and use of LCC in the individual countries. The work concluded in a in January 2001, that it was a large potential for a common further development by establishing a Nordic network group. After this a main project was established consisting of the 5 Nordic countries; Norway, Sweden, Denmark, Finland and Island, and several people within each country.

It was highly important to establish a common Nordic model and specification for making LCC calculations and environmental key figures and get it all implemented in the building industry in all the Nordic countries. The Nordic network established has national sub networks and the sub-groups shall give active contribution to the development, implementation and further development of the model.

Through this project it has become evident that the Nordic countries have a relatively similar view, methods and goals about the use of LCC – calculations. The outcome of the project is a common platform / model for costs specification of LCC. The classification system is based on existing classification systems in Norway, Denmark and the Netherlands and devides costs into 8 main groups:

1. Capital
2. Administration
3. Operation
4. Maintenance
5. Development
6. Consumption
7. Cleaning
8. Service

A further splitting up in sub categories can be as shown:

- One-figure level states a main item, example: 6. CONSUMPTION
- Two-figure level states a service, example: 63. Waste handling
- Three-figure level states an activity, example: 63.1 Internal transport
  63.2 Compression
- Four-figure level states a resource 63.1.1 Equipment, salary

The Norwegian sub-network is divided into several workgroups that are responsible for different subjects within the area. Among the subjects are:

- LCC-tools
- Level of calculation related to purpose
- Organisation and documentation in construction projects related to environment- and lifecycle considerations.
- Specifications and contractual relations
- Key figures
- Architecture in a lifecycle perspective

RIF has the responsibility to act as an active coordinator for all the working-groups.

To strengthen the Nordic building industry the implementation of the Nordic model of LCC calculations and evaluations will be of high value. Throughout the network and sub networks it will be arranged several workshops which will be designed for competence upgrading on LCC calculations into the companies. The established network has a competence base that gives synergies in the further work. It is also important that the network has direct contact to companies in the industry as well as R&D institutions and universities.

Norwegian Facility Management Network

Norwegian Facility Management Network (NfN), was established in 1992, and has since 1993 conducted an annual benchmarking process amongst the members. Initially the processes covered mainly CRE (Commercial Real Estate) management but are now extended to include a broader span of FM key areas.

The activities include 4-6 thematic conferences per year covering important professional issues and excursions to interesting development projects, and a number of professional networking groups where the practitioners can exchange experiences digging deeper into their key figures. Other important objectives are to facilitate bilateral benchmarking and enhance the development of internal benchmarking routines within the member companies.

It has been a NfN policy to keep the number of member companies within certain limits in order to facilitate close membership relations and to focus on quality in benchmarking key performance and work processes with limited administrative operating cost. As of today NfN has approximately 35 members and is a member of EuroFM. The ambition is to contribute actively to the development of closer relations with particularly the Nordic members in EuroFM through the Nordic FM-network (www.nordicfm.org).

All the Norwegian network groups has a close relation with The Norwegian University of Technology and Science and other relevant educational institutions in order to influence and sustain professional developement (www.metamorfose.ntnu.no).

FURTHER WORK

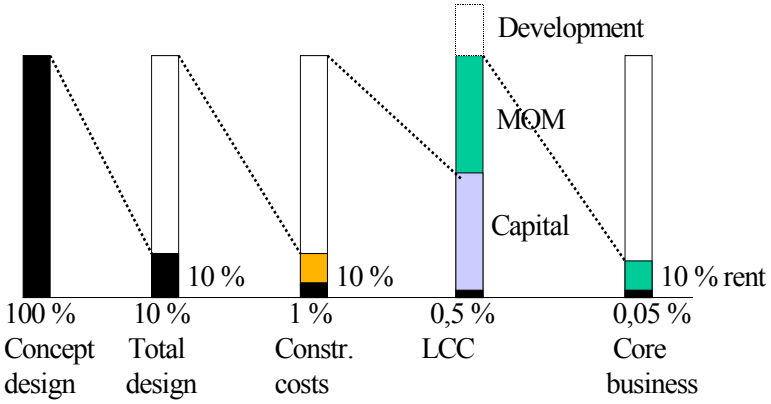
Experiences from the last 10 –15 years, and the increasing interest in property/facility management, indicates that the focus in the short term will be on:

- LCC with calculations as early as possible
- Life cycle planning (LCP) will become more common
- The concept / design phase will include a wider range of specialists, such as expertise in MOM, and in accommodating the user's needs.
- First service life period (1. SLP) will decide demands for adaptability.
- "Total economy" will become more important.

Consept Design Phase

In particular the concept design phase should be given a lot of resources in relation to LCC. If this phase represents 10% of the total design costs, it would represent about 1% of the building costs, and only 0,5% of LCC (see figure 9). For an ordinary office user, the rent would normally represent about 10% of the operating costs. If we assume that the rent should cover LCC, the concept design phase would represent 0,05% of the total operating costs of the organisation using the offices. Despite the relatively small proportion of the costs, the concept design phase could have a significant influence on the total economy of this organisation.

Development costs could become heavy if the organisation frequently demands changes. It is worth considering whether additional investments could reduce such demands for changes. In other words, predicting 1. SLP will become important as shown in fig. 10.



Figur 9. Cost of consept design compared with other cost elements (Ref S. Bjørberg, Multiconsult)

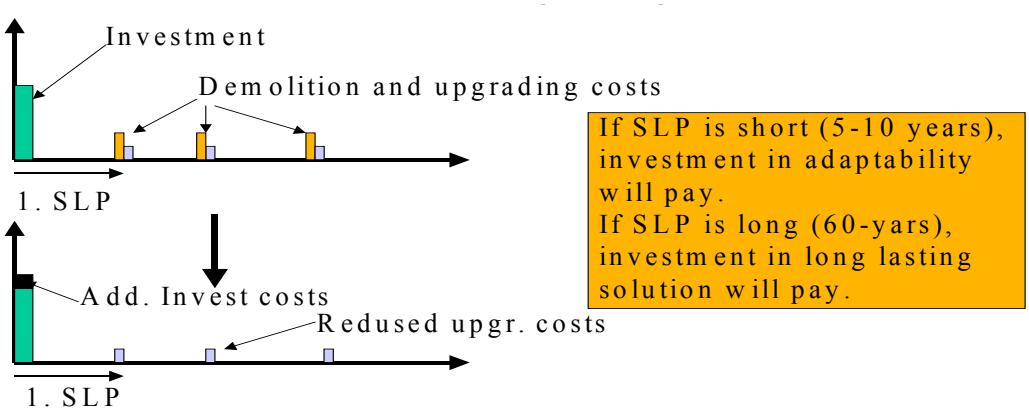


Fig 10. Service Life Periode (SLP) (Ref S. Bjørberg, Multiconsult)

Adaptability

Adaptability of buildings will probably become more important in the future. The term "adaptability" is defined (in an ongoing R&D-project run by Multiconsult), as a function of:

- Flexibility (F) Possibility for changing layout
- Generality (G) Possibility for changing function
- Elasticity (E) Possibility for changing volume

In this project the development of a classification system is essential, see fig 11. Four categories (levels) have been defined, each category corresponding to the level of fulfilment of certain requirements on adaptability. In the classification system level 0 represents high adaptability and 3 represents low adaptability. Figure 11 illustrates the need of being adaptable in different categories of buildings. Culture/monumental buildings often only have a small need of being adaptable, for example an opera-building. An hospital, on the other hand, have to be very adaptable in order to meet rapidly changing demands. When using this methodology it is necessary to know what the requirements on each level are too be fulfilled. In that respect a number of thematic help-matrixes are developed (see table 3).

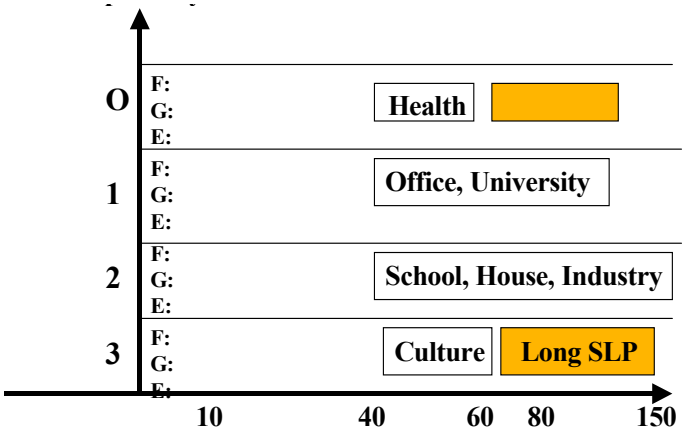


Fig 11. Levels of adaptability requirements (Ref S. Bjørberg, Multiconsult)

Key Performance Indicators (KPI)	Adaptability					
	Level 0	**Level 1**	**Level 2**	**Level 3**	**LEVEL**	**COMMENT**
FLEXIBILITY						
INTERNAL WALLS DOORS AND WINDOWS	Walls, doors and windows easy to mount and take down. Little technical installations in walls. Standarised connections.	Some walls, windows doors rigidly connected to other elements, but mainly easy to change plan layout.	Walls, doors and windows difficult to move.	Heavy and rigid internal wall construction and many partitions.		
LOADING CAPACITY **Dead-load**	Floors can handle extensive dead-loads. (e.g. storage)	Floors can handle most activities.	Limits for heavy dead loads.	Strict dead-load limitations.		
Live-load	Floors can handle extensive live- loads. (e.g. fitness centre)	Floors can handle most activities	Limits for activities with considerable movements. (e.g. fitness centre)	Strict live-load limitations.		
Snow-load						
EMERGENCY EXITS	Emergency exits are satisfactory according to current regulations and standards for several different building purposes.	Conversion to new solutions and current standards and regulations can be made within reasonable ease.	Considerable deviation from the requirements for current standards and regulations or to adapt to new use. Mending possible within a practically and economically justifiable frame.	Mending not possible within a practically and economically justifiable frame to meet current standards and regulations.		
FURNITURE	Furniture is easy to fit into most parts of the building, is easily adapted to equipment and technical installations and is easy to move around.	Furniture can mostly be moved and fitted into new rooms and solutions.	Most of the furniture can be moved around, but moving is heavy and furniture is not transformable.	Extensive use of stationary furniture. Heavy large and difficult to move. Old furniture which is difficult to adapt to new technical solutions.		
CONFLICTS BETWEEN BUILDING ELEMENTS (Open Building)	Little conflicts between the different main building elements with different lifetime . Easy to maintain and replace separately.	Main building elements can be replaced and maintained separately.	Bad planning for element separation.	Rigid connections between different building elements.		

Table 3. Example on classification matrix (Ref A. K. Larssen, Multiconsult)

When evaluating existing buildings one could use the same set of demands to classify the building. If we put a hospital in category 2, and the demands are that a hospital should be in category 0, it must be considered whether to rebuild and upgrade the hospital. It could mean that the core business would have a sub standard building, and therefore higher than the optimal level of operating costs. Considering the total economy, it could be better to demolish the building, or convert it for other use.

The same methodology can be used to analyse existing buildings, evaluating how a building meets demands of flexibility, generality and elasticity. Figure 12 illustrates a building from 1930

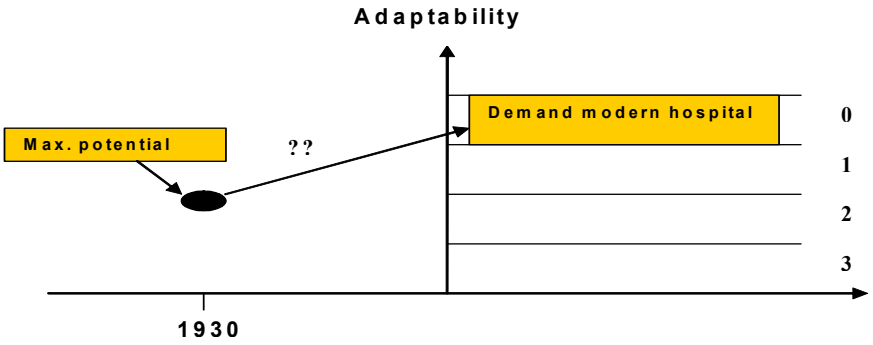


Figure 12. A building from 1930 has a maximum potential to satisfy the demands of Grade 2 while the demands for a modern hospital is 0 (Ref. Multiconsult AS).

that satisfaying the demands of Grade 2. Refurbishment of a building for use as a hospital, where the demands are grade 0, is hardly practical or economically feasible. A building not meeting the core business' demands for building services may cause the business extra costs due to lack of functionality. The health production will hence be less effective as in an optimal building.

Improving the data

Collecting large amounts of data based on experience, such as key figures and Key Performance Indicators in databases is essential in order to improve the Service Life Planning of a construction. In Scandinavia we are well on the way with establishing databases and networks. Further development within LCC will probably give:

- Better and more key figures by coordination of the data available. This will provide a better insight in today's cost levels. We know that maintenance is not sufficiently funded, and that this has led to an accumulated maintenance gap.
- The key figures will give us a better basis for providing reference levels for the core businesses to maintain their level of efficiency over time.

This should again let us establish future goals or reference levels for consumption of energy and other resources.

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