

# Life cycle economics: State-of-the-art in the Nordic countries

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## Summary

The ability to estimate and evaluate economic consequences in a lifetime perspective is becoming increasingly important. In preparation for a major Nordic project, a study has surveyed the state-of-the-art on life cycle economics in the Nordic countries. A state-of-the-art report concluded that: 1) Differing terminology and methodologies are being used with present value of costs and annualised costs being predominant. 2) A variety of IT-based tools are available for calculating life cycle costs. 3) Key figures are being collected in all Nordic countries several different cost classifications are in use. 4) Several networks exist in all Nordic countries except Iceland, but most actors within the real estate and construction cluster do not systematically apply life cycle economics to their activities.

*Key words:* Life cycle costing, life cycle profit, annualised costs, present value, key figures, database, IT-based tools, networks

## 1. Introduction

The 24 million inhabitants of the Nordic countries have at their disposal a building stock of more than 2,100 million m<sup>2</sup> floor area which increases with approx. 1-2 % per year. The value of the properties amounts to approx. 1,500 billion €, and the costs of operating these properties is estimated of approx. 110 billion € per year.

*Table 1. Building stock in the Nordic countries.*

	Norway	Denmark	Sweden	Finland	Iceland
<b>Inhabitants (million persons)</b>	4.5	5.3	8.9	5.2	0.3
<b>Floor area (million m<sup>2</sup>)</b>	325	638	655	420	70
<b>Annual increase (million m<sup>2</sup>)</b>	7	7.5	6	5	1.5
<b>Property value (billion €)</b>	400	350	500	250	20
<b>Operating costs (billion €)</b>	20	25	35	30	-

Note: Different reference years, definitions and data validity. Estimated operating costs. Source: Adapted from [1].

The renewal, operation and ownership of the building stock are rapidly changing. Private companies, municipalities and state government increasingly try to liquidate capital by turning towards professional facility managers to take over the responsibility of building, operating and owning facilities. Thus the ability to estimate and evaluate the economic consequences in a lifetime perspective of decisions regarding facilities is becoming more important.

## 2. Method

The state-of-the-art report [1] was a collaborative effort involving several researchers and practitioners in the five Nordic countries in the period 1999-2001. In each country a national working group was established to draft national reports, while the cross-national analysis was conducted by a 3-member steering committee. The work was divided into four steps:

- Design of the analytical framework focusing on four aspects: Terminology and methodology; key figures and databases; IT-based calculation tools; and Nordic and national networks.
- Data collection based on workshops and/or interviews with key persons during a 1-2 day visit by the steering committee in each of the Nordic countries.
- Analysis of the national state-of-the-art of life cycle economics based on existing literature, statistics etc. Despite a rather detailed outline, the national reports are to some extent divergent.
- Analysis of the state-of-the-art of life cycle economics across the five Nordic countries.

This paper is based on an extensive bulk of literature. Only the most important publications are referenced in this paper, but a complete list of literature can be found in [1].

### 3. Results

#### 3.1 Norway

Around 1978, the interest in life cycle economics was spurred off when the Norwegian association of consulting engineers introduced the term “årskostnader” at its annual meeting. The term was defined as the annualised costs over a given period. Since then, a number of handbooks, guidelines etc. have been published on the subject. Later, the term became the subject of the Norwegian standard NS 3454 [2], which defines the costs according to 6 main categories and a number of subcategories:

- 1. Capital costs.
- 2. Management costs.
- 3. Operating costs.
- 4. Maintenance costs.
- 5. Development costs.
- 6. Unused (to be defined by the user himself for special purposes related to the building).

Three additional categories related to facility management are defined for servicing/support for the core activities (e.g. catering services), potential of the property, and one unused category to be defined by the user for special purposes.

The classification of costs would however be of no use without access to valid key figures. Key figures can be obtained from different sources:

- Public statistics from the central statistics office as well as from a number of Norwegian government agencies like Statsbygg (real estate management), NVE (energy and water), SINTEF (health care and universities) and municipalities.
- Associations like nfb (“nøkkeltall for byggeri”) offers benchmarking to the members based on historical data from actual buildings.
- Private consultants specialised in facility management.

For numerous years, Statsbygg has been one of the main drivers in the practical implementation of life cycle costing. From 1 September 1998 Statsbygg made life cycle costing mandatory in all their building projects. In order to systemise and ease the calculations, Statsbygg developed a tool called LCProfit (“Årskostnadsanalyse”) based on the spreadsheet Excel. All external consultants must calculate the life cycle costs of a project with this tool, and two years after inauguration of the facility, the consultants will have to participate in a survey to assess the realised versus the expected life cycle costs. The tool has been adopted by several public and private clients and is now the leading tool in Norway. It has also been translated into English and Danish.

One of the most important networks was created in relation to the Norwegian standardisation committee on NS 3454 and more recently the ongoing work within ISO TC 59/15686 on service life planning. Secondly, networks and activities regarding facility management, life cycle costing and key figures have been established around the Norwegian association for maintenance and associations organising clients and building owners from both the public and the private sectors. A

third type of network is active within research and development. Fourthly, Norwegian actors participate in international networks on e.g. facility management.

### 3.2 Denmark

In Denmark, the interest in life cycle costs was spurred by the oil crisis in the 1970s. Focus was primarily on energy costs and usually calculations were limited to estimating simple payback times. During the 1980s, the perspective on life cycle economics expanded into such areas as maintenance-friendliness, guidelines were published on calculating life cycle costs using present value, and other costs than energy costs came to be included in calculations. In the beginning of the 1990s, focus was further expanded to include facility management with the establishment of a Danish association on facility management (DFM) and a second closely related association for those involved in benchmarking and key figures on facility management. In the late 1990s, the Danish government realised that the implementation of life cycle economics was too weak. By 1 January 1998 the government made it mandatory to conduct life cycle costing in social housing projects and government building projects.

Data for calculating life cycle costs can be obtained from a number of sources:

- Public statistics from the central statistics office as well as from a number of Danish government agencies like National Agency for Enterprise and Housing (social housing and urban renewal), the Danish Energy Authority (energy consumption), and the mandatory energy management scheme ELO for buildings exceeding 1500 m<sup>2</sup> (heating, electricity and water).
- Associations like DFM offers benchmarking to the members based on historical data from actual buildings (approx. 4.6 million m<sup>2</sup>).
- Private consultants specialised in price calculations (especially V&S Price Books) and facility management.

However, data are collected for numerous purposes and following different classifications. An overview of the most important cost classification schemes in Denmark can be seen in Table 2. Within social housing, the former Ministry of Housing (now National Agency for Enterprise and Housing abbreviated EBST) has for almost 20 years collected 3 main categories and approx. 28 subcategories of data on acquisition costs for new building projects [3]. The agency also collects data from the annual budgets of the housing associations covering around 500,000 dwellings. The data are divided into 5 main categories and approx. 30 subcategories [4]. Furthermore, the agency collects acquisition costs for urban renewal projects divided into approx. 35 categories, which can broadly be summarised into 4 main categories [5].

Table 2. Classification schemes.

<b>EBST</b> <b>- acquisition costs</b> <b>for social housing</b>	<b>EBST</b> <b>- annual budgets for</b> <b>social housing</b>	<b>EBST</b> <b>- acquisition costs</b> <b>for urban renewal</b>	<b>DFM</b> <b>- key figures for facility</b> <b>management</b>	<b>V&amp;S Price Books</b> <b>- construction and</b> <b>maintenance costs</b>
Site costs	Net capital costs	Capital costs	Permanent property costs (not capital costs)	Information costs
Construction costs	Water and sewage costs	Construction costs	Supply costs	Costs for building parts
Other costs	Cleaning costs	Consultancy costs	Cleaning costs	Site costs
	Net maintenance costs	Administration costs	Maintenance costs	Project costs
	Other costs		Shared operating costs	Supply costs
				Cleaning costs
				Maintenance costs
				Shared operating costs

In the late 1980s, BPS published what turned out to be a de facto standard for DFM dividing the life cycle costs into 5 main categories [6]. It should also be noted, that the building information centre Byggecentrum publishes the V&S Price Books broadly following the SfB-system for classifying building elements. They contain both construction costs and maintenance costs. V&S Price Books are widely used for calculations of both construction budgets and maintenance budgets, although

not specifically for life cycle costing.

In relation to the required mandatory life cycle costing, the former Ministry of Housing had an IT-based tool called TRAMBOLIN developed by a private consultant. But other tools existed e.g. integrated calculation modules in facility management systems and stand-alone tools. Other tools were developed for more narrow purposes, like energy cost optimisation developed by a private consultant or Green Accountancy developed by Danish Building and Urban Research. Furthermore, the Norwegian Statsbygg's tool has been translated into Danish and the tool has had significant influence on a similar tool developed by Danish Defence Construction Service. But besides that, a number of price calculation systems like V&S Price Books could (with some manual calculations) be used to calculate life cycle costs or simple payback times.

The work on life cycle costing and facility management has taken place for more than 20 years and a number of networks and associations have been created to disseminate knowledge and benchmark on key figures. The most prominent are the two Danish associations on facility management with one focusing exclusively on key figures and the other dealing with facility management in more general terms. A third association is the Danish society of maintenance. Along with these formalised networks a number of informal networks have been created e.g. between the largest social housing companies in Copenhagen, between municipalities in the so-called Triangle Area in Jutland, and research networks.

### 3.3 Sweden

There are two main methods of life cycle economics in Sweden:

- Life Cycle Profit (LCP): The purpose is to estimate the profitability of an investment. The method is often used on competitive markets. Focus is on the net result of the incomes minus the costs. Cash/flow-analysis can be used in various forms.
- Life Cycle Costing (LCC): The purpose is to estimate the costs during the economic life cycle of an investment. LCC is part of LCP. LCC calculations can be used to calculate e.g. the necessary rent to cover the costs (break-even) or the optimal intervals of maintenance from an economic point of view. Like in Norway, the term “årskostnader” is often used for the annualised costs.

More than 20 years ago, the Swedish Association of Municipal Housing Companies (SABO) and the Swedish Property Federation developed the first common standard for cost classification for real estate management. According to the latest version (FastBAS 97), costs can be classified in 10 main categories and for each main category up to 10 subcategories. The 10 main categories can be divided into roughly 4 groups [7]:

- Supplementary information, statistics etc. (class 0).
- Balance sheet: Assets (class 1) and liabilities (class 2).
- Result: Income (class 3), administration (class 4), other external costs (class 5 and 6), personnel (class 7), and financial income and expenses (class 8).
- Unused, but designated internal bookkeeping (class 9).

It is also worth noting that since 1995 Sweden has had an “Agreement for Property Management” (Aff) for procurement of property management [8]. In relation to the standard, an extensive number of documents have been developed including a list of terminology and standards forms and manuals.

During the 1980s, Swedish researchers carried out a number of major statistical studies on housing which generated databases containing validated cost data. But these databases have not been updated. A number of other databases exist that contain data on building costs and maintenance. However, the data quality as well as the coverage is diverse. One of the most prominent databases is provided by the private consultant REPAB on annualised costs (“årskostnader”) for six building types: Housing, schools, offices, kinder gardens, health care, and industrial facilities. Another database is related to the Swedish Property Index, where 15 large building owners co-operate in order to build a database with economic data concerning housing and commercial facilities.

Historically, Sweden has had a flourishing number of IT-based tools within this field. A number of

consultants have developed applications, which can be used to calculate life cycle costs. In the near future, promising research projects will be trying to integrate calculations of life cycle costs with object-oriented databases (ITBygg2002) and develop a GIS-based tool to support maintenance management and cost calculations (WoodAccess and MMWood).

There are no formalised networks in Sweden aimed at life cycle economics. Usually, ad hoc networks or project-specific groups are established to solve concrete problems like the active involvement of the Swedish standardisation organisation in drafting the coming ISO 15686 standard. Due to the low inflation rates in recent years, the interest in life cycle economics has increased in Sweden. Thus, a group of researchers at KTH in Stockholm are now working on a more or less permanent basis with issues related to life cycle economics and linked with a network of approx. 25 companies.

### **3.4 Finland**

In Finland, planning and control of life cycle costs has been rather sporadic since it has not been widely demanded by clients or building owners. Thus, no terminology of cost classification or methodology on life cycle economics has so far emerged as a de facto standard.

Still for more than 20 years, the building information foundation RTS (Rakennustietosäätiö) has gathered cost data according to the Finnish building specification system [9] for construction costs. The Building Economy Laboratory, Technical University of Helsinki, publishes statistics on actual real estate maintenance costs. Furthermore, the joint service and research institute KTI Institute for Real Estate Economics provides benchmarking and key figures for about 50 large property owners covering approx. 1.800 facilities. KTI Institute for Real Estate Economics is also responsible for the Finnish property index.

A number of tools has been developed and are in use in Finland especially for housing:

- Investment analysis including cash flow analysis and risk analysis is offered by KTI Institute for Real Estate Economics.
- Property asset management systems have been developed by various consultants to optimise portfolios of properties and some may include LCC calculations.
- Stand-alone tools like TILA-SUKU developed by private consultants and the technical research centre VTT for life cycle costing. The tool is used by a number of large property owners like Nokia.
- Modules for life cycle costing as part of facility management systems developed by private consultants.
- Single-purpose tools aiming at optimising one single aspect (predominantly energy) of the management, operation and maintenance of a facility.

A number of on-going activities are taking place to further develop and implement tools etc. It is worth noting that the Finnish research agency TEKES and the Finnish association for building owners and clients RAKLI have co-financed a so-called life cycle clinic. The purpose of the clinic is to develop and commercialise innovations concerning life cycle economics and life cycle assessments.

Several networks are established within the research community, single associations etc. Across these networks, a number of networks have been established in relation to the life cycle clinic as well as in relation to some large EU-funded R&D projects like LIFETIME or EuroLifeForm.

### **3.5 Iceland**

The interest in life cycle economics has been very weak on Iceland for a number of reasons. First of all, the construction industry has primarily been occupied with new buildings since Iceland experienced a major building activity during the 1960s, 1970s and 1980s. Thus, the majority of buildings on Iceland are rather young – the average age is approx. 25 years. Secondly, about 70-80 % of the building stock is owned by the users themselves who very actively participate in both construction and maintenance of their own buildings. Thus, professional facility managers are rare.

However, there are now signs of a changing situation. The focus of the construction industry is shifting towards renewal of three reasons. First, the new-built activity is rapidly diminishing and the average age of buildings is increasing. Second, the government is trying to free up capital through outsourcing of facilities. Third, more and more companies are shifting from ownership to rental of facilities. Thus, the interest in life cycle economics is increasing in Iceland but starting from a rather immature situation without any fixed terminology or dominant methodologies.

There are no publicly available databases containing information on life cycle costs except for a research project investigating 120 houses in Iceland. Thus, it is hard to benchmark and evaluate the performance of individual facilities. Some key figures on certain topics do, however, exist:

- The building cost for two different types of buildings is calculated regularly and used as basis for an official building cost index.
- Some building owners have over time gathered data related to specific facilities, but generic key figures are not available.
- Two private consultants collect key figures for building, maintenance and repair costs of different components to be used in planning and calculation of construction budgets.
- The institute for real estate evaluation (Fasteignamat Ríkisins) systematically collects and publishes price figures for sold houses on the market, in different regions and for different types of buildings.

For several years, two large house owners and the municipality of Reykjavik have systematically dealt with maintenance, and two larger housing companies plan their maintenance based on key figures from other Nordic countries.

Although there is hardly any market for life cycle economics in Iceland, two private consultants have each developed IT-based tools which can be used for calculating life cycle costs. One tool is a rather simple Excel based tool, whereas the other is a much more comprehensive facility management tool.

In Iceland, there are no networks or associations directly associated with life cycle economics. Attempts have been made to create such networks but have failed so far.

## 4. Conclusion

This study has surveyed the state-of-the-art of life cycle economics in the Nordic countries in preparation for an on-going Nordic project. Table 3 gives a summary of the characteristics of each country. It should be noted that the summary may have some minor divergences and omissions.

*Table 3. State-of-the-art in the Nordic countries.*

	Norway	Denmark	Sweden	Finland	Iceland
<b>Terminology</b>	NS 3454	EBST DFM V&S Price Books	FastBAS 97 Aff definitions REPAB	Building 90	-
<b>Methodology</b>	Annualised costs	Simple payback time Present value	LCP & LCC (annualised costs)	Annualised costs	-
<b>Key figures</b>	Public statistics Nfb Consultants	Public statistics DFM Consultants	Public statistics REPAB Property Index	RTS Building Economy Lab. Property Index	Few owners 2 consultants
<b>IT-tools</b>	LCProfit	TRAMBOLIN FM module Energy optimisation Price calculations	Flourishing field	Investment analysis Property asset management LCC tools FM module Energy optimisation	1-2 tools
<b>Networks</b>	Standardisation committee Associations R&D networks	Several associations Local networks R&D networks	Standardisation committee Ad hoc networks R&D networks	Associations Life cycle clinic R&D networks	-

The state-of-the-art report concluded that:

- Across the Nordic countries, several different cost classifications are in use. Norway is the only Nordic country with a national standard on cost classification, while both Sweden and Denmark have different cost classifications working as de facto standards within well-defined fields.
- Methodologies differ across the Nordic countries. Life cycle economics have more or less become synonymous with discounted cash flows (especially of costs) but other methodologies like the simple payback method do exist and are being used. Net present value is primarily used in Denmark, whereas annualised costs are mostly used in Norway, Sweden and to some degree in Finland. In Iceland, the situation is rather immature.
- In each country, there are a variety of IT-based tools available to calculate life cycle costs. Five types of tools can be identified: Investment analysis, specific stand-alone tools, modules for facility management systems, price calculation systems, and single-purpose tools for optimising one single aspect (predominantly energy).
- Key figures for benchmarking are collected in all countries, with Denmark having the most elaborated benchmarking systems and with Iceland having very limited access to key figures. However, key figures are collected for different building types and using different cost classifications. Thus, key figures are not immediately comparable – even within each country.
- Several more or less permanent and formalised networks are established for actors interested in life cycle economics in all the Nordic countries except Iceland. But besides this rather narrow group of committed actors, the majority of actors within the real estate and construction cluster do not care much about life cycle economics.

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State of the Nordic Region 2018 presents facts and figures from the Nordic countries on core socioeconomic areas. Image bank. In this section, you can search for images with a Nordic theme. eHealth standardisation in the Nordic countries Technical and partially semantics standardisation as a strategic means for realising national policies in eHealth. Publication number. 2019:537. The Nordic countries have been called "mixed economies" precisely because they combine elements of socialism and capitalism: state and private ownership of the means of production; public regulation and market competition; redistributive taxes and wages determined by employers and employees. If the socialists of today ignore capitalism's role in that mix, they fail to follow their own leading lights. This leads to the third lesson. Much of the Nordic model's success is rooted not in direct state intervention but in the finely balanced interplay between social organisations, especially in the labour market. Admirers appreciate the role of unions in the Nordic economies; they are less aware of the equal importance of coherent employers' associations. The Nordic nations have gone much further down the road to gender equality than anywhere else in the world. By comparison, some of G8 nations, especially France, Italy and Japan, have a lamentable record. But few countries are emulating the Nordic models. On June 11, 2013, it will be 100 years since Norway became the first independent country to introduce the vote for women. There will be tremendous celebrations all over Norway, a country which is proud of its egalitarian society. All five Nordic countries " an area with a collective population of 26 million - were among the first nations to g