LCC & SERVICE LIFE PLANNING

ISO15686 Is Coming

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LCC and different other life cycle techniques and activities (standards & norms, requirements, technologies, theories, methods, software etc) are emerging today the most important development within the Construction and Real Estate Cluster – CREC. The series ISO15686: "Buildings and constructed assets - Service life planning" is rapidly offering new tools for the life cycle planning of buildings or other constructed assets. This study is to summarise the ongoing development.

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Executive summary

Introduction

LCC and different other life cycle techniques and activities (standards & norms, requirements, technologies, theories, methods, software etc) are emerging today the most important development within the Construction and Real Estate Cluster – CREC. Important standard development is taking place in the ISO technical committee TC59 “Building construction”, particularly in its subcommittee SC14 “Design life”. The series ISO15686: “Buildings and constructed assets - Service life planning” is rapidly offering new tools for the life cycle planning of buildings or other constructed assets.

Objective and actions done

This study is to summarise the ongoing development. It starts with a review of sustainable construction and new related international documents. Then it describes the ongoing work towards ISO15686 standards, particularly ISO15686-1 “General principles” and ISO15686-5 “Life cycle costing (Whole life costing)”. Special attention is paid to confusion and discrepancies appearing around ISO/DIS15686-5 “Whole life costing”. Finally, better definitions for lcc-related items, new thinking for discount rates, the monetarisation of all impacts, and LCC with probabilistics are discussed.

Findings

CREC represents a quarter of the EU15 gross domestic product. Thus the sustainability of CREC is most important for whole society. Better definition is needed for sustainable construction.

Several new reports and documents are reviewed. They have been published recently by the European Commission, International Council for Research and Innovation in Building and Construction – CIB, a Nordic task force, and others. They all aim at a more sustainable construction and promote LCC considerations.

Development work since late 90s towards ISO15686 standards has produced four ready parts (standards) plus documents in their various stages towards altogether ten parts. ISO15686-1 “General principles”, the umbrella standard, proves to be very informative and useful in many respects.

A draft standard ISO/DIS15686-5 “Whole life costing” also brings forward many good issues. Unfortunately, a fundamental part of the paper is totally confusing and in contradiction with the umbrella standard. The confusion lingers about the introduction of Whole Life Cost(ing) – WLC, a British wording, to replace internationally recognised Life Cycle Cost(ing) – LCC (the work is headed by British Standards Institution - BSI). Also the arithmetics used diverts from commonly known and understood formulas. This all is to alienate the prospective users from the new standard. These problems are discussed in the report. Finland has produced a revision for ISO15686-5, where WLC is changed back to LCC, as it is in the umbrella standard. In the international ISO voting, this change was supported by Sweden and Norway.

Under ISO 15686-9 “Terminology” the above confusion is further discussed. New harmonised definitions are proposed by this writer for life cycle (lc), life cycle cost (lcc) and life cycle costing (LCC). Accordingly “**Life cycle costing is a technique which enables comparative cost assessments to be made over a period of analysis, taking into account all relevant economic factors both in terms of initial capital costs and future operational costs. Where**

the term uses initial capital letters it can be defined as the present value of the total cost of an asset over the period of analysis."

In ISO15686-5 the discount rate is not properly dealt. The differences between nominal and real discount rate and their mathematical relationship are not properly described. Also their importance and optimal use has been left unclear, and their levels open. For this, a brief introduction is included to the four rooms of economies, descriptively called **Natural** (d=0% = simple payback), **National** (3%), **State** (6%) and **Business** (9%) economies, as introduced by this writer late 2003.

To replace LCA scorings and points with easy to understand monetary values, a brief introduction to **Total LCC** is presented, as first time introduced by this writer 1998. Here LCC is to cover not only the initial capital and direct future costs of a building or another constructed asset but also externalities and intangibles (occupational, locational, environmental and societal costs). To put it simply, Total LCC just tries to convert all various impacts to money. After this monetarisation everything can be calculated mathematically as LCC = NPV of all effective costs over the period of analysis. This is supported by ISO15686-5

Finally, a summary is given about a major European RTD project EuroLifeForm (Probabilistic Approach for Predicting Life Cycle Costs and Performance of Buildings and Civil Infrastructure). Its purpose is to replace deterministic (read: historic singular) values for costs and performance (read: service life) with a probabilistic approach. Monte Carlo analysis / Latin Hypercube simulation are used by the software @Risk 4.5 Industrial. Developed **LCCP Wise™** software tools are briefly presented, particularly their role in service life prediction. This is supported by ISO15686 and related the CIB reports.

Conclusions & recommendations

Internationally recognised standards and practices should be developed; ISO, CEN. This is particularly true for the EU15 and the whole EU25 to fulfil the objectives of the open internal market.

Discrepancies appearing in the development work of ISO15686 should be amicably solved.

The value of the LCC calculations should be made better understood, including the role of suitable discount rates.

New methods should be developed for the ease of understanding and application. Monetary values in Euros or Dollars are easy to understand instead of different ratings, scorings and points.

For LCC and other life cycle techniques to become widely accepted, concerns about uncertainties in forecasting should be overcome: (1) costs and (2) performance of a building or another constructed asset; its components, assemblies and systems, maintenance and management over its life.

Espoo 03 May 2005

Olavi TUPAMÄKI

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1 Objective

Very important standard development is taking place in the newly reorganised ISO technical committee TC59 "Building construction", particularly in its subcommittee SC14 "Design life". The series ISO15686: Buildings and constructed assets - Service life planning is rapidly offering new tools for the life cycle planning of buildings or other constructed assets. So far this series covers 10 parts: the first 4 parts are ready and the remaining parts advanced.

This study is to summarise the ongoing development. The study concentrates particularly to the issues related to life cycle costs (lcc) and life cycle costing (LCC).

2 Intro

LCC and different other life cycle techniques and activities (standards & norms, requirements, technologies, theories, methods, software etc) are emerging today the most important development within the Construction and Real Estate Cluster - CREC in Finland, Europe and the world. Yet, it appears that the lack of knowledge and misconception are prevalent within the decision-makers and experts alike, as well as the various CREC stakeholders.

- A lot of work is done at all levels. Often, however, this work seems to be insular and growing on a national or other narrow basis.
- Internationally recognised standards and practices should be developed; ISO, CEN. This is particularly true for the EU15 and the whole EU25 to fulfil the objectives of the open internal market.
- New methods should be developed for the ease of understanding and application. Monetary values in Euros or Dollars are easy to understand instead of different ratings, scorings and points.
- For LCC and other life cycle techniques to become widely accepted, concerns about uncertainties in forecasting must be overcome: (1) costs and (2) performance of a building or another constructed asset; its components, assemblies and systems, maintenance and management over its life.
- All the above development is necessary to achieve sustainable construction, and it affects directly to the business environment of the CREC industries. The expected results of this development are good for investors/developers/owners, designers, contractors, facilities managers, users and other stakeholders.

3 What about sustainable construction?

3.1 What is sustainable development?

"Sustainable development is a matter of satisfying the needs of present generations without compromising the ability of future generations to fulfil their own needs" [Brundtland report, *Our Common Future*, 1987]. Sustainable development means sustainability not only ecologically (= environmentally) and economically but also socially and culturally.

Lately in the EU and UN, an expression "the three pillars of sustainable development" is often used; the pillars are said to concern economic, environmental and social development. For not to forget cultural aspects, they should read economic, environmental and societal (= social, cultural, ethical etc) development.

Now it appears that also ISO in its fresh documents, eg *ISO/CD15392 Sustainability in Building Construction – General Principles* (23 Dec 2004), seems to cement its approach on these three pillars and tries to extend the meaning and contents of “social” to be equal to “societal”. This writer looks like giving up but is not satisfied: Eg for a nation, language is the most important aspect to survive, yet it is not even mentioned. This is **human-diversity** to be preserved just like any bio-diversity in general. Globally, according to UNESCO statistics, a half of the spoken languages, ie some 3,000 languages, are facing death. In the EU15 there are 35 local small languages, and not all they are officially recognised. Without its own Finnish language manifested in 1863 there now would be neither Nokia nor Finland at all as an independent country!

After Kibert’s definition 1994, for sustainable construction CIB W82 (OT a member) proposed the following definition 1998: "The creation and responsible management of a healthy built environment based on resource-efficient and ecological principles". This definition is not satisfactory, as it leaves out economic and societal issues completely! A later programme document *Agenda 21 on Sustainable Construction* (CIB Report Publication 237, 1999) adds some considerations to it, yet a better definition is needed.

3.2 Could this be sustainable construction?

The ways in which built structures are procured and erected, used and operated, maintained and repaired, modernised and rehabilitated, and finally dismantled (and reused) or demolished (and recycled), constitute the complete cycle of sustainable construction activities.

Minimise the use of materials, energy and water and mobility (factor 4/10; NL: factor 20).

Building products should, as far as possible, be reusable and materials recyclable. Design for long service life (and durability) is superior to design for reusability. Reusability is superior to recycling, and recycling is superior to waste disposal. In sustainable construction, reusability and ease of changeability are necessary product properties, in particular for modular products and systems with different service lives.

According to *ISO/CD15392 Sustainability in Building Construction – General Principles*, eco-efficiency is typically achieved by following the seven basic guidelines:

- reduce the material intensity of goods and services
- reduce the energy intensity of goods and services
- reduce toxic dispersion
- enhance material recyclability
- maximise sustainable use of renewable resources
- extend product durability
- increase the service intensity of products.

3.3 Why sustainable construction is important?

In advanced European vocabulary "construction" is considered to cover the entire value chain of develop/own, design, manufacture, construct, recycle a building, infrastructure or other constructed assets. In Finland and elsewhere, a new expression Construction and Real Estate Cluster - CREC has been taken to use to cover all activities directly related to construction and real estate (buildings, infrastructure and other facilities = 60-70% of the national wealth). Compared to the above, CREC covers the whole life of a building, hence additional activities concern running the building, which more often is done by facilities management.

A reason to this approach is the fact that major contractors are moving from plain construction towards taking care of the building/facility for its whole life. Also public-private partnership projects (BOOT, PFI; toll roads & bridges, schools, prisons etc) require this approach. All investors and property developers need this. And any sustainable construction consideration requires CREC!

While in Finland construction represents 10% of GDP (or 12% if repairs & refurbishment are counted in), CREC represents over 30% of the same GDP ($CREC_{gdp}$= 37GEUR= 26%).

Accordingly, in the EU15 construction represents 10% of the total GDP, and CREC a quarter of the same GDP!

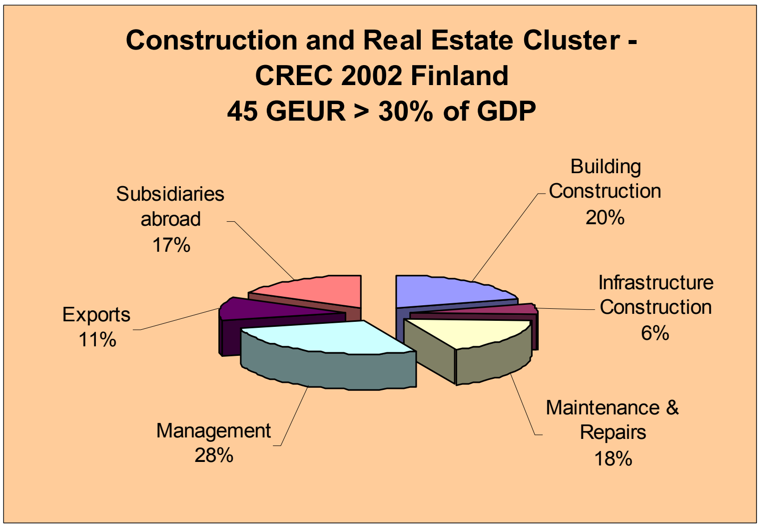

Figure 1 CREC, year 2002 Finland (source: VTT)

By weight, construction activities consume up to 50% of all raw materials used and produce over 40% of waste (yet, mostly recyclable, and reducing rapidly in enlightened countries).

Buildings consume 40% of total energy and account for 30% of CO_2 emissions, thus environmentally alone, CREC's sustainability is most important for whole society!

4 What are LCC and LCA?

4.1 Definitions

It is important to understand the fundamental differences between LCC and LCA. Thus, already here at the beginning of the study I present the "initial" definitions as developed and used by this writer during the past several years. These definitions are in conformance with the related standard, yet not directly borrowed from their text.

Derived from ISO 14040: In CREC, **environmental life cycle assessment - LCA** is for assessing the total environmental impact associated with a product's manufacture, use and disposal and with all actions in relation to the construction and use of a building or another constructed asset. LCA does not address economic or societal aspects!

Derived from ISO 15686: In CREC, **life cycle costing - LCC** is a technique which enables comparative cost assessments to be made over a specified period of time, taking into account all relevant economic factors both in terms of initial capital costs and future operational costs. In particular, it is an economic assessment considering all projected relevant cost flows over a period of analysis expressed in monetary value. Where the term uses initial capital letters it can be defined as the present value of the total cost of an asset over the period of analysis.

4.2 LCC in construction – new EU reports

In its report ***An agenda for sustainable construction in Europe*** completed in June 2001, an industry-led working group for Sustainable Construction with participants from the European Commission, Member States and Industry (OT a member) and working for the EC DG Enterprise's agenda on the Competitiveness of the Construction Industry recommends that "All member states and accession countries should be encouraged to draw up and publish plans and programmes for sustainable construction".

As a result of the above report, in late 2001 a task group TG4 (OT a member) was established by the EC DG Enterprise to "Draw up recommendations and guidelines on Life Cycle Costs - LCC of construction aimed at improving the sustainability of the built environment". The group tries to find models for practical application of sustainable construction based on present value – PV of economic and environmental factors. Societal factors (social, cultural, ethical etc) were unfortunately left out.

The final report ***Life cycle costs in construction*** was approved 29.10.2003 in a tripartite meeting in Brussels, comprising representatives from the Commission, member states and industry (OT a member). The paper, printed July 2004 and supposedly distributed to all member states, makes seven recommendations to advance the use of LCC, as follows:

- Adopt a common European Methodology for assessing LCC of construction
- Encourage data collection for benchmarks, to support best practice and maintenance manuals
- Public procurement and contract award incorporating LCC
- Life cycle cost(ing) indicators should be displayed in buildings open to public
- Life cycle cost(ing) should be carried out at the early design stage of a project
- Fiscal measures to encourage the use of LCC
- Develop guidance and fact sheets

This writer was a major contributor to this document, particularly on definitions and how to calculate. Also its appendices *7.3 EuroLifeForm* (Probabilistic Approach for Predicting Life Cycle Costs and Performance of Buildings and Civil Infrastructure) and *7.6.6 Summary of the presentations to TG4 given by Mr O. TUPAMÄKI* are fully my writing. The report also repeats the LCC definition as written above.

This guide discarded the UK expression of whole life cost(ing) - WLC as globally unknown, confusing and misleading, and sticks to LCC and commonly used formulas for calculation (for more, see later).

A new Communication from the European Commission titled ***Towards a thematic strategy on the urban environment*** came out in February 2004. It is the first step towards the EU's Sustainable Urban Environment Strategy. This report was prepared by independent experts from CREC and commission officials. It covers four domains: management, transport, construction and design. It correctly recognises that sustainability is not about environment only but also economic and societal impacts should be duly considered; elements such as life cycle costs, indoor air, noise, accessibility, comfort and risks (others can be easily added). To a major extent it is built on the earlier documents.

This document is to create further actions in the EU and CEN towards related regulatory guidance and standards (Ari ILOMÄKI of Finnish Forest Industries participates from FI; OT a member of RT's Finnish Mirror Group).

4.3 New CIB reports

Late March 2004, a pretty comprehensive ***Performance based methods for service life prediction - state of the art reports*** (CIB publication 294) was completed by CIB W080 / RILEM 175 SLM Service Life Methodologies - Prediction of Service Life for Buildings and Components. It covers two parts, Part A - Factor Methods for Service Life Prediction and Part B Engineering Design Methods (EDM) for Service Life Prediction. As conclusion and outlook it reads: As opposed to using simple numerical factors in the original factor method, this (EDM) approach incorporates the use of probability density functions for factors as well as for the service life of individual components to arrive at an overall estimate of a building's service life.

Early April 2004 came out also a related publication ***Guide and bibliography to service life and durability research for building materials and components*** (CIB publication 295) completed by Joint CIB W080 / RILEM TC 140 - Prediction of Service Life of Building Materials and Components. This report, published in five parts totalling 377 pages and 5.7 MB, contains fundamental knowledge on service life prediction and related topics. Among other things, the report is stating that the service life cannot be expressed as a single deterministic value but described in stochastic terms with the aid of a probability density function.

In addition, it can be mentioned that OT is a member of the CIB commission W080 – Prediction of Service Life of Building Materials and Components, under which the above documents were prepared. This commission also contributes to the development of ISO15686 standards, and several members (including OT) are directly participating in both activities.

4.4 Nordic LCC report

Early 2005 came out a new report ***LCC for byggverk***, jointly prepared by the actors from the Nordic countries (Sakari PULAKKA of VTT participated from FI; OT a member of the Finnish expert group). A common Nordic model and classification system of costs for LCC calculations has been established. The classification system is based on existing classification systems in Norway, Denmark and the Netherlands.

The project has produced input to the international work initiated by ISO/TC 59/SC 14 "Design Life", of which LCC forms a part, and in this way ensures that the Nordic points of view are taken into account in the new standards. The results of the project are also introduced in the work of establishing a CEN standard on Facility Management (FM) where LCC forms a central part as well.

5 Development of ISO15686 – Buildings and constructed assets – Service life planning

Very important standard development is taking place in the newly reorganised ISO technical committee TC59 “Building construction”, particularly in its subcommittee SC14 “Design life”. The series ***ISO15686: Buildings and constructed assets - Service life planning*** is rapidly offering new tools for the life cycle planning of buildings or other constructed assets.

5.1 ISO15686 – 10 parts

So far this series covers 10 parts: the first 4 parts are ready and the remaining parts advanced, and the first part "umbrella standard" already under revision. The proposed ten parts are as follows:

- *ISO 15686-1 “General Principles”* deals with issues and data needed to forecast service lives and gives a method for estimating the service lives of components and assemblies; umbrella standard; approved 2000.
- *ISO 15686-2 “Service Life Prediction Principles”* describes a generic method for using testing of performance of components and assemblies to provide a service life prediction; approved 2001.
- *ISO 15686-3 “Performance audits and reviews”* provides tools for audits and reviews to ensure that relevant steps have been taken to achieve a service life that will match or exceed the design life; approved 2002.
- *ISO 15686-4 “Data requirements”* is a technical guide on methods of presenting data and evidence to support forecasts.
- *ISO 15686-5 “Life cycle costing”* (or “Whole life costing”) will provide guidance on life cycle costing.
- *ISO 15686-6 “Procedure for considering environmental impacts”* will provide guidance on assessing environmental sustainability in the context of service life planning; approved 2004.
- *ISO 15686-7 “Performance evaluation and feedback of service life data from existing construction works”* will provide guidance on how to structure and use feedback data on in-use condition.
- *ISO 15686-8 “Reference service lives”* provides guidance on assessment of default service lives using available information.
- *ISO 15686-9 “Terminology”*.

- *ISO 15686-10 "Description of the data required in estimating service life"* provides guidance on methods of presenting data and evidence to support forecasts and predictions.

5.2 ISO 15686-1 "General Principles"

This standard deals with issues and data needed to forecast service lives and gives a method for estimating the service lives of components and assemblies. This is supposed to be an umbrella standard, and other parts should be in conformance with it. The principal content is as follows:

1 Scope
2 Normative references
3 Terms and definitions
4 Abbreviated terms
5 Process of service life planning
6 Service life planning: Steps in the design process
7 Service life forecasting
8 Service life prediction based on exposure and performance evaluation
9 Factor method for estimating service life
10 Financial and environmental costs over time
11 Obsolescence, flexibility and reuse

Annex A Typical financial costs of buildings over time (in UK and USA)
Annex B Examples of critical property assessment of alternative specifications
Annex C Agents affecting the service life of building materials and components
Annex D Examples of requirements
Annex E Method for estimating service life of components using factors to represent agents
Annex F Worked examples of factorial estimates

This standard is very informative and useful in many respects. Here I touch only a couple of features, as follows:

5.2.1 Service life

Design life = intended/expected/required service life [as per 3.1.4 design life = intended service life (deprecated); expected service life (deprecated); service life intended by the designer]

Design life of building	Inaccessible or structural components	Components where replacement is expensive or difficult (incl. below ground drainage)	Major replaceable components	Building services
Unlimited	Unlimited	100	40	25
150	150	100	40	25
100	100	100	40	25
60	60	60	40	25
25	25	25	25	25
15	15	15	15	15
10	10	10	10	10
NOTE 1 Easy to replace components may have design lives of 3 or 6 years.				
NOTE 2 An unlimited design life should very rarely be used, as it significantly reduces design options.				

Figure 2 Suggested minimum design lives for components (DLC)

Service life = period of time after installation during which a building or its parts meets or exceeds the performance requirements [as per 3.1.1]. The following descriptions show the consequential relationship of different service lives to each other.

- *Predicted service life*, from recorded performance over time, accelerated ageing tests etc [as per 3.1.5 predicted service life = service life predicted from recorded performance over time; eg as found in service life models or ageing tests] ➔

- *Reference service life*, as expected in a certain set of in-use conditions [as per 3.1.2 reference service life = service life that a building or parts of a building would expect (or is predicted to have) in a certain set (reference set) of in-use conditions] ➔
- *Estimated service life*, as expected in a set of specific in-use conditions, ie as per the particular project on hand [as per 3.1.3 estimated service life = service life that a building or parts of a building would be expected to have in a set of specific in-use conditions, calculated by adjusting the reference in-use conditions in terms of materials, design, environment, use and maintenance]

5.2.2 Factor method for estimating service life

This method allows an estimate of the service life to be made for a particular component or assembly in specific conditions. It is based on a reference service life (normally the expected service life in a well-defined set of in-use conditions that apply to that type of component or assembly) and a series of modifying factors that relate to the specific conditions of the case.

EXAMPLE: If the reference service life of a window is 20 years, a modifying factor of 0.8 might be used to estimate the window's service life in an exposed position. The estimated service life would then be 20 * 0.8 = 16 years. But if a particularly rigorous inspection and maintenance regime were to be applied to ensure that minor defects did not develop into more serious problems, then a further modifying factor of 1.4 might be applied. The estimated service life would then be 16 * 1.4 = 22.4 years. Note that factors of less than 1 reduce the estimated service life and factors of more than 1 increase it.

The reliability of the reference service life figure is critical, as it will affect the estimate proportionally.

This method uses modifying factors for each of the following:

- factor A: quality of components
- factor B: design level
- factor C: work execution level
- factor D: indoor environment
- factor E: outdoor environment
- factor F: in-use conditions
- factor G: maintenance level.

Any one (or any combination) of these variables can affect the service life. The factor method can therefore be expressed as a formula:

ESLC = RSLC * factor A * factor B * factor C * factor D * factor E * factor F * factor G

As opposed to using simple numerical factors, also other more sophisticated methods can be used, such as eg proposed in the CIB publication 294 above, which incorporates the use of probability density functions for factors as well as for the service life of individual components to arrive at an overall estimate of a building's service life. This probabilistic approach is further developed in a European RTD project ***EuroLifeForm*** (Probabilistic Approach for Predicting Life Cycle Costs and Performance of Buildings and Civil Infrastructure) (for more, see later).

The starting point of the factor method is the **reference service life**. It is a documented period in years that the component or assembly can be expected to last in a reference case under certain well-defined service conditions. It may be based on the following:

a) data provided by a manufacturer, a test house or an assessment regime (for innovative components it will normally be based on the manufacturer's or supplier's exposure results); this may be a single figure or a distribution of typical performance;

b) previous experience or observation of similar construction or materials or in similar conditions;

c) Boards of Agreement in the EC state assessments of durability in their certificates or reports of national product evaluation services;

d) some books which are available and which include typical service lives;

e) building codes which may give typical service lives for components.

5.2.3 Life cycle costing (LCC)

Life cycle assessment (LCA) should not be confused with life cycle costing (LCC). It is a broader concept which entails identifying the "cradle to grave" resources consumed and/or effects on the environment throughout the service life of a product, such as a building (see ISO 14040).

Life cycle costing (also known as whole-life or through-life costing) is **a technique which enables comparative cost assessments to be made over a specified period of time**, taking into account all relevant economic factors both in terms of initial capital costs and future operational costs. Being able to compare the future costs of alternatives allows selection of the most economic overall design and helps planning and control of the cost of ownership. This subject will be covered in more detail in ISO 15686-5. Some essential features include the following.

a) Only designs and/or components which meet the design life, functional and performance requirements should be considered as alternatives.

b) Alternatives which meet the performance requirements but which have lower life cycle costs should be preferred.

c) LCC should be undertaken on the entire estimated service life of the whole building and its components and assemblies, or on a less-foreseeable service life.

d) All relevant economic factors, including opportunity costs (ie cost of choosing this investment rather than another), should be included within the analysis.

e) Initial costs include costs directly related to the whole building and its components and assemblies, including design, construction and installation, fees and charges.

5.3 ISO 15686-5 "Life cycle costing" (or "Whole life costing")

A draft standard ISO/DIS15686-5 "Whole life costing" also brings forward many good issues. Unfortunately, a fundamental part of the paper is totally confusing and in contradiction with the umbrella standard. The confusion lingers about the introduction of Whole Life Cost(ing) – WLC, a British wording, to replace internationally recognised Life Cycle Cost(ing) – LCC (the work is headed by British Standards Institution - BSI). Also the arithmetics used diverts from commonly known and understood formulas. This all is to alienate the prospective users from the new standards.

The development work of this part has been dragging along for years, stopped, cancelled and rewritten several times. Originally its title was "Life cycle costing" as per the umbrella standard. Later it was changed to appear as "**Whole life costing**". Although this looks like a small semantic difference, it actually reflects throughout the standard, and makes it fundamentally bad (for more, see later under 6.1 and 6.2). In the following the latest version of ISO/DIS 15686-5 dated 29 Mar 2004 is described, unless otherwise stated. The principal content is as follows:

1 Scope
2 Normative references
3 Terms and definitions
4 Abbreviated terms
5 Principles of Whole Life Costing
6 Appraisal of options/alternatives
7 Decision variables — How to calculate WLC
8 Uncertainty and risk — How to make a decision using WLC
9 Reporting

Annex A Worked examples — Analysis techniques used in WLC
A.1 Present Value calculation

Here again the most interesting items are repeated and/or described, as follows:

5.3.1 Whole life costs

In this standard the term used is Whole Life Costs, but it is important to be aware that not all users will be currently using the scope and definitions indicated in this part of ISO15686.This is graphically illustrated in the following figure.

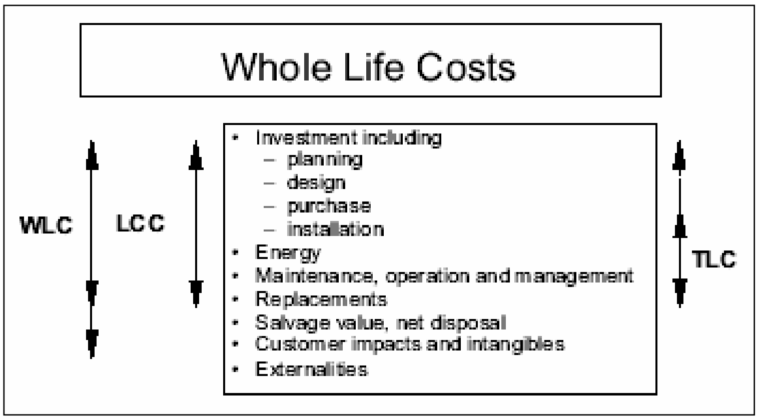

Figure 3 Relationship between different terms included within Whole Life Cost – WLC

LCC = life cycle cost
TLC = through life cost

MY COMMENT: This is bullshit

Whole Life Costing is a broad term, which covers a wide range of analysis, and includes within it several alternative terms that may be more familiar, such as life cycle costing, through life costing and lifetime costing. Sometimes all the terms are used interchangeably but generally the latter phrases are more narrowly interpreted. Typically, through life costs or lifetime costs cover the life cycle of the asset from acquisition to start of the disposal phase (excluding disposal and/or replacement). Life cycle cost typically covers a defined list of costs over the physical, technical, economic or functional life of a constructed asset or over some other defined period.

Life cycles of assets or projects consist of four distinct phases, as shown in following figure.

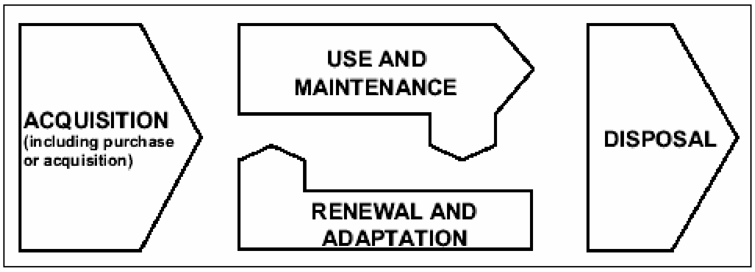

Figure 4 Life cycle phases

5.3.2 Period of analysis

When considering the period of analysis, issues which may cause the unplanned end of service life or a change of use (such as technical, functional, demographic or aesthetic obsolescence) should be taken into account in the WLC analysis by performing a sensitivity analysis. A sensitivity analysis will examine alternative uses. Alternatively the analysis may exclude options that would require re-use.

Typical periods of analysis include:

a) the period of foreseeable need or occupation of the constructed asset;

b) a period determined by a contractual liability (eg for maintenance of the asset or for a mortgage financing the investment);

c) a standard investment analysis period applied within an organization.

The period of analysis is a critical variable. Costs occurring outside the period of analysis may significantly impact on the client costs of ownership. Such costs may include heavy maintenance costs due after the end of a period of analysis (and/or associated loss of performance) and the residual value of the asset. It is therefore frequently necessary to review the results over several periods of analysis.

5.3.3 Introducing cost variables

Values for the costs should be as accurate as possible. Greater effort may be required for the most significant cost variables. Values can be derived from:

a) a direct estimation from known costs and components;

b) historical data from typical applications;

c) models based on expected performance, averages etc; and

d) best guesses of future trends in technology, market and application.

For each cost, whether a cost element or a detailed cost category, there should be an associated time profile of when the cost occurs (or recurs) for Whole Life Costing to be carried out. Time profiles of the costs may only consist of one occurrence but any cost spread over time or one that is repeated will generate a series of cost and time pairs. Costs may be fixed or variable over time. These values are most readily converted into calculations using a computer spreadsheet or purpose-built software.

The costs should be expressed in current terms as many financial or tax transactions are based on actual values at the time rather than the value in future (eg the current cost of a boiler should be used, not a projected future cost).

Computer models set up for sensitivity and risk analysis should ideally be totally in parametric form, ie each value should be related to a parameter that, when changed, will cause all other costs derived from it to change. Alternatively, logical analysis and checking of variables should be performed with each change.

5.3.4 Discount rate

The discount rate when expressed in real terms can be applied to costs (and benefits) that are also measured in real terms, as opposed to nominal (cash) terms. It represents the opportunity cost of investing the capital, which might be:

a) the interest cost of a loan for the investment;

b) the interest lost on reduction of cash on deposit;

c) returns lost on investment elsewhere (eg in bonds or equities);

d) the actual return achieved on capital investment in the business;

e) the required rate of return of an investor in a new business;

f) a factor determined by central government as a test requirement for their investments.

NOTE This rate may be imposed by an authoritative source, eg the current rate imposed in the UK is set by the Treasury for projects undertaken for the government and is based on as assessment of the long term opportunity cost to government of selecting one investment rather than another.

5.3.5 Inflation

Future inflation is highly uncertain. Those analysing WLC should avoid making assumptions about the general rate of inflation whenever possible. However, if this is unavoidable, assumptions should be explicit and the sensitivity should be checked.

5.3.6 Taxes

Taxes and subsidies can affect the relative price and the decision-making process. It is important to adjust for any incidence of tax arising from different options being considered. The existence of tax subsidies associated with the investment should be included.

5.3.7 Utility costs including energy costs

Where an assessment is made of energy costs, present day supply costs should be used unless it is foreseeable that the relative costs will change between alternative energy sources. Where an investment appraisal is assessing energy efficient technology, energy or utility savings should be treated as a future income stream for comparison purposes.

5.3.8 Externalities

WLC can ensure optimality in asset selection, maintenance and use. However, assumptions made about the optimality of investment choices are often based purely on market efficiency and fail to recognise the wider implications economic decisions have on society. Market prices often do not value the social costs or benefits of production and consumption.

A common approach by government in dealing with externalities is the imposition of regulatory taxes on negative externalities and subsidies for the external benefits. Analysis that considers the external costs and benefits is relevant in a WLC model because possible options may have real costs and revenues because of such government action. WLC analyses that consider the occurrence of externalities may therefore highlight possible future risks and rewards not otherwise identified.

NOTE: Analyses described as TLC (through life cost) or LCC (life cycle cost) rarely include externalities, and generally externalities and customer impacts are optional for inclusion within a WLC analysis.

5.3.9 Environmental cost impacts

Environmental legislation may introduce costs (or savings via rebates) to WLC depending on the effects that the building's location, design, construction, use and disposal place on the environment. Examples could include cost premiums for the use of non-renewable resources or for green house gas emissions. ISO15686-6 will provide further guidance on environmental sustainability.

5.3.10 Social costs

Costs associated with processes that have an impact on the service provider/customer but are not paid by the customer for the WLC analysis are frequently omitted from the calculation, but may be included if the client's brief so requires. In this case it is critical to clearly define the limits on what is included.

5.3.11 Sustainable building/environmental building

Life cycle assessment (LCA) is a method of measuring and evaluating the environmental burdens associated with a product, system or activity, by describing and assessing the energy materials used and released to the environment over the life cycle. LCA can be used to measure the impact of externalities and therefore be used to aid WLC decisions that include a measure of the external cost of investment. Consideration of the environmental impact of potential investments allows for the delivery of decisions also based on sustainability issues. Further guidance on LCA is found in the ISO14000 series of standards and the link between service planning and LCA is dealt with in ISO15686-6.

The integration of service life planning into the procurement and management of constructed assets may involve assessment of the cost implications of adopting sustainable building policies and/or strategies. WLC may also be relevant when assessing compliance with legislation on e.g. carbon trading or avoidance of landfill.

5.3.12 Intangibles

The demand for a built asset is a consequence of a higher demand for a business or operational process: for example, a demand for a training capability will often generate a demand for a training facility. Improvements in a built asset can affect the users' comfort, amenity and efficiency. This will often create non-quantifiable improvements that lead to increased satisfaction and efficiency, which may have financial implications (eg improvement in morale leading to reductions in absence through stress). This is an added value to the built asset.

Examples include:

a) advertising for the business - land mark buildings provide prestigious status symbols;

b) functionally efficient buildings may increase user satisfaction;

c) pleasant working conditions may increase the productivity of the workforce, leading to direct improvements to the business case for investment.

*MY NOTE: Paras 5.3.2…12 fully accommodate my **Total LCC** thinking; particularly 5.3.8…12 directly support my idea of monetarising the different external and intangible impacts. See the following:*

*To overcome the LCC + LCA problem, I try to look at it purely arithmetically. In the book "Construction Can!" published by arrangement of ENCORD in 1998 (ENCORD = European Network of Construction Companies for Research and Development. The book is available free of charge in our online bookshop at www.villareal.fi), I introduced a fresh approach to LCC to cover not only the initial capital and direct future costs of a building or another constructed asset but also **externalities and intangibles (occupational, locational, environmental and societal costs)**, as shown below.*

To put it simply, Total LCC just tries to convert all various LCA impacts to money. After this monetarisation everything can be calculated mathematically as LCC = NPV of all effective costs over the period of analysis.

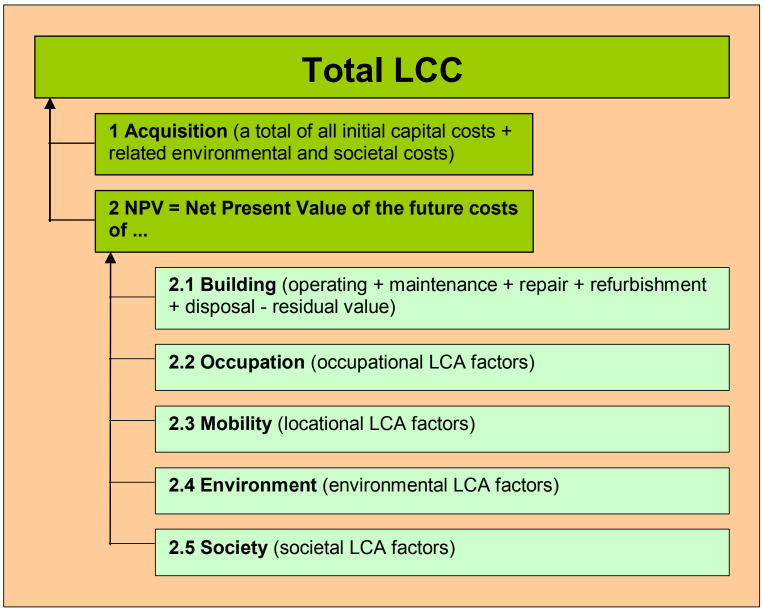

Figure 5 Total LCC – monetarising all impacts

Think this is impossible? For mobility this is easy and customarily done. For occupational factors more and more studies are coming out eg in the USA, Finland etc showing the value of various office properties / features in productivity and expressed in monetary terms. Eg for environmental impact, the environmental profiles of construction materials, components and elements are in a good progress in *the UK, Denmark, Finland and elsewhere. These profiles already have been converted to Ecopoints (GB) or equivalent CO_2 (DK) or CO_2 plus full profile of other environmental impacts (FI). After this, monetarisation shouldn't be impossible.*

Measuring the monetary value of something does not require that it be sold and bought in markets.

5.3.13 Real costs

To ensure accuracy in cost considerations, current costs are generally used. Using real costs allows current known information to be used in an analysis of a process. For this analysis, a base date should be set in the recent past or near future. A recent or near future date is usually chosen because people are familiar with the current cost and the cost environment in which they live, work or think.

A value in real cost is the monetary amount to be paid if the cost occurred at the base date, regardless of which point in time it occurs. A year is referred to when using real costs because of general price inflation and because future prices may not necessarily change at the same rate for all items.

5.3.14 Nominal costs

Real costs are not generally appropriate for preparing financial budgets where the actual monetary sums will be needed to ensure funding is available when required. Nominal costs are ascertained from projected economic, technological and efficiency factors. The nominal cost is related to the real cost by the expected general price inflation.

5.3.15 Discounted costs

Discounted costs are calculated by taking costs that occur in future years and reducing them by a factor derived from the discount rate. Different discount rates apply depending on whether nominal costs or real costs are being discounted. With nominal costs, the discount rate should include an inflation factor. If real costs are used, the discount rate should not include an inflation component.

Different discount rates also apply to different organizations and individuals. The discount rate reflects the preference for money now rather than later. The discount rate is the interest rate that would make it just worthwhile for the decision-maker to spend money in one year's time rather than now. It is also the rate by which future income would need to be discounted each year for the decision-maker to prefer to have it now rather than in one year's time.

MY NOTE: To convert a real and/or nominal cost to a discounted cost, unfamiliar (yet mathematically correct) formulas are presented. The following description would be proper:

The Net Present Value – NPV procedure reduces a series of cash flows which occur at different times in the future to a single value at one point in time, the present. The technique which makes this transformation possible is called discounting. As generally mathematically true, and also guided by the EC report Life cycle costs in construction, LCC is calculated as NPV of the accumulated future costs (C) over a period of analysis (t), eg 25 years (N), at an agreed discount rate (d), eg 1% (= 0.01) pa dependant on prevailing interest and inflation rates. NPV is calculated according to the following formula, and can be done with eg MS Excel (up to 29 years easily...).

$$NPV = \sum_{t=0}^{N} \frac{C_t}{(1+d)^t}$$

NPV can be calculated using nominal costs and discount rate based on projected actual future costs to be paid, including general inflation or deflation, and on projected actual future interest rates. Nominal costs are generally appropriate for preparing financial budgets, where the actual monetary amounts are required to ensure that actual amounts are available for payment at the time when they occur.

NPV can be calculated also using real costs and discount rate, ie present costs (including forecast changes in efficiency and technology, but excluding general inflation or deflation) and real discount rate (d_{real}), which is calculated according to the following formula, where (i) = interest rate and (a) = general inflation (or deflation) rate, all in absolute values pa.

$$d_{real} = \frac{1+i}{1+a} - 1$$

To make the LCC approach significant for improving the sustainability of the built environment and the related calculations easier to understand, real costs and discount rate are useful. At low discount rates long-term future costs and savings are meaningful also at present.

5.3.16 Present value (PV)

The present value is the cost found by discounting future cash flows to the base date. The present value is used for comparing alternatives over the same period of analysis. Present value calculations are used to calculate the present monetary sum that should be allocated for future expenditure on an asset. This is because the value for money is not constant with the passage of time.

5.3.17 Net Present Value (NPV)

The sum of the discounted benefit of an option less the sum of the discounted costs is the Net Present Value of that option. It represents therefore a single figure that takes account of all relevant future incomes and expenditure over the period of analysis.

MY NOTE: If incomes are considered zero (or residual value only included), NPV is equal to PV as defined in this standard. As most people are much more familiar with NPV than PV, I prefer to use NPV in my own papers and formulas. As I have already done above under 5.3.15.

Also, it is good to notice that if the discount rate is zero (d=0), NPV is equal to simple payback.

5.3.18 Payback (PB)

Payback is a calculation of the time period it takes to cover investment costs. It is a calculation of the number of years elapsed between the initial investment and its subsequent operating costs and the time at which cumulative savings offset the investment. Simple Payback takes real (non-discounted) values for future monies. Discounted payback uses present values. Payback in general ignores all costs and savings that occur after payback has been reached. When considering investment with future expenditure, a discounted payback may be used to reflect the time value of money. It is possible that an investment with a short payback is a poorer option than one with a longer payback when looked at over the entire period of study. Generally, however, payback is a useful technique to compare large and small investments.

5.3.19 Uncertainty and risk

Confidence in the results of WLC analysis depends on the existence and use of the relevant information, the assumptions made, any omissions or exclusions and the input data used in the analysis. Erroneous conclusions may be drawn and wrong decisions made due to the use of incorrect data or the omission of cost-significant items.

The distinction between uncertainty and risk is that “risk” is used when probabilities can be estimated and uncertainty is used when they cannot.

5.3.20 Monte Carlo analysis

Where a range of possible costs is calculated it may be beneficial to model the uncertainty attached to the cost variables using statistical techniques such as Monte Carlo analysis. This will allow a distribution of possible costs to be identified and more or less probable figures to be used in calculations. Frequently, for example, a client will require costs to be estimated at 10 %, 50 % and 90 % confidence levels. Software programs are available to model uncertain values using Monte Carlo analysis and similar statistical techniques.

5.3.21 Sensitivity analysis

Sensitivity analyses can be undertaken to examine how variations across a (plausible) range of uncertainties could affect the relative merits of the options being considered and compared. These ranges should be likely, within the limits of what is anticipated, and fit within the client’s brief. This will identify which input data have the most impact on the WLC result and how robust the final decision is.

The uncertainties that should be considered include:

a) discount rates;

b) the period of analysis;

c) incomplete or unreliable service life data based on assumptions.

Sensitivity analysis is an important guide to assess what further information it would be worthwhile to collect and what the most significant assumptions that have been made are. Sensitivity analysis involves iterating the sensitivity analysis calculation with a range of values for the variable data. The analysis will indicate the vulnerability of the WLC to variations in this respect. If the sensitivity analysis indicates that alternative variables have little effect on recommendations, the decision will be unaffected. If however the recommended option is varied by different discount rates/ service lives etc being applied it may indicate that further analysis is required or that the decision is based upon factors other than WLC.

*MY NOTE: This probabilistic approach is greatly developed in a European RTD project **EuroLifeForm** (Probabilistic Approach for Predicting Life Cycle Costs and Performance of Buildings and Civil Infrastructure) to replace deterministic (read: historic singular) values for costs and performance (read: service life) with a probabilistic approach, good for investors/developers/owners, designers, contractors, facilities managers, users and other stakeholders. Monte Carlo analysis / Latin Hypercube simulation are used by the software @Risk 4.5 Industrial.*

As an example, a contractor can use LCCP (LCC with Probabilistics) software in his tendering for a BOOT or other type PPP or private project. As shown in the chart below, he is able to make a well informed decision on the final tender price based on probability, or risk he is ready to take. Risk involved he can also reduce by scenarios and more accurate source data.

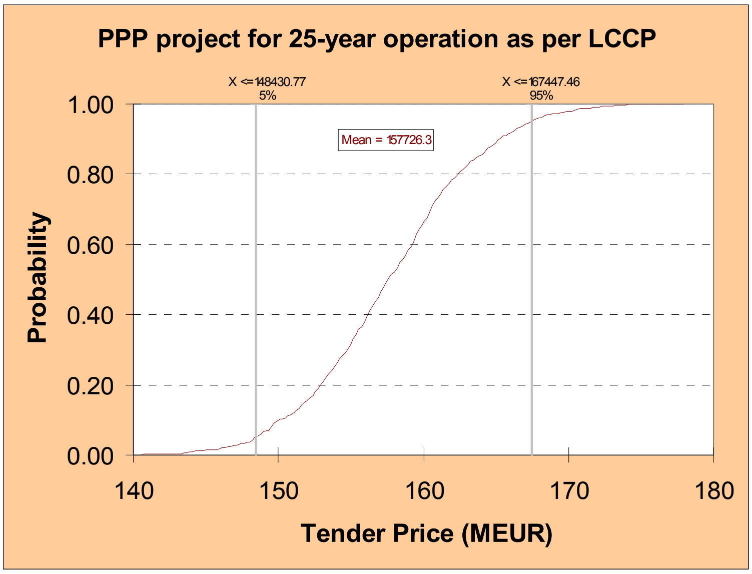

Figure 6 The outcome of tender computing utilising LCCP Wise™ software

A pack of models to enable a lifetime design process utilising the LCCP approach was developed. Visual Basic 6 is utilised to increase versatility, enable integration and to improve user friendliness.

*The integrated pack and its modules are wiser than the insular deterministic methods currently in use. Thus the name **LCCP Wise™** for the software pack.*

5.4 ISO 15686-9 "Terminology"

Towards Part 9, a working document was created December 2004 listing the terms and definitions now appearing in different ISO15686 documents. They are partly compromising and conflicting between each others and against other existing ISO standards.

5.4.1 ISO/CD15392 Sustainability in building construction - General Principles

A new committee draft ISO/CD15392 came out December 2004. This standard aims to establish general principles to be considered when addressing the thematic field of sustainable building. The scope of sustainable building is broad, many aspects of concern lie well outside the scope of ISO TC59 Building Construction.

In its scope it is written "This international standard is based on the concept of sustainable development and establishes a rationale for related standards." This means it tries to take a role of grand umbrella standard.

Yet, in 7.1 it is written "Buildings must meet numerous requirements, expressed and established in national and international standards, as well as in regulative documents. None of these is replaced or changed with the establishment of this international standard."

Considering its relation to other existing and under development ISO, CEN and other standards, the objective is not realistic. Also, the rationale as it is now written is neither comprehensive nor convincing.

5.4.2 Definitions comparison

In the following table I present several important, “fundamental” terms borrowed from related ISO standards. The comparison shows differences and contradictions, which should be corrected in the ongoing development work of ISO15686 series.

In addition, I present my own suggestions for harmonised definitions, which are in conformance with ISO15686 and harmonised & compatible between themselves. It looks important to define separately life cycle cost (money) and life cycle costing (analysing technique/methods), as actually in ISO15686-1 already has been done. In these definitions I have tried to follow ISO15686 different existing expressions and wordings. These definitions I proposed in March 2005 to RT’s Finnish Mirror Group and directly to ISO as well.

Term	**ISO/CD15392 Sustainability in building construction/ General Principles, 2004**	**ISO15686-1 Buildings and constructed assets - Service life planning - General principles, 2000**	**ISO/DIS15686-5 Buildings and constructed assets - Service life planning - Whole Life Costing, 2001…04**	***OT’s suggestions, March 2005***
life cycle	3.8 consecutive and interlinked stages of a product system, from raw material acquisition or generation of natural resources to the final disposal Note: This definition is the same as 3.8 in **ISO14040 Environmental management - Life cycle assessment - Principles and framework, 1997**		4.15 (2001) The period of time between a selected date and the cut-off year or last year, over which the criteria (eg costs) relating to a decision or alternative under study is assessed. Note. This seems the same as the period of analysis - but it does need definition to avoid confusion 4.15 (2002) The period of time between a selected date and the cut-off year or last year, over which the criteria (eg costs) relating to a decision or alternative under study is assessed. This period may be determined by the client for the analysis (eg to match the period	*period of time between a selected date and the cut-off year or last year, over which the criteria (eg costs) relating to a decision or alternative under study is assessed. This period may be determined for the analysis (eg to match the period of ownership) or on the basis of the probable physical life of the asset itself.* [<= ISO/DIS15686-5]

			of ownership) or on the basis of the probable physical life-cycle of the asset itself. 4.15 (2003) The period of time between a selected date and the cut -off year or last year, over which the criteria (eg costs) relating to a decision or alternative under study is assessed. This period may be determined by the client for the analysis (eg to match the period of ownership) or on the basis of the probable physical life-cycle of the asset itself 3.3.7 (2004) The period of time between a selected date and the cut-off year or last year over which the criteria (eg costs) relating to a decision or alternative under study are assessed. This period may be determined by the client for the analysis (eg to match the period of ownership) or on the basis of the probable physical life-cycle of the asset itself	
life cycle cost **(whole life cost)**		3.7.5 total cost of a building or its parts throughout its life, including the costs of planning, design, acquisition, operations, maintenance and disposal, less any residual value	4.33 (2001) The overall estimated cost for a particular program alternative over the time period corresponding to the life of the program, including the costs of planning, design, acquisition, operations, maintenance and disposal, less any residual value. 4.33 (2002) An economic assessment considering all agreed projected significant and relevant cost flows over a period of analysis expressed in monetary value. Where the term uses initial capital letters it can be defined as the present value of the total cost of an asset over the period	*total cost of a building or its parts over a period of analysis or up to the end of its life, including the costs of planning, design, acquisition, operations, maintenance and disposal, less any residual value* [<=ISO15686-1, ISO/DRAFT15686-5]

			of analysis. It is implicit that the projected costs are to achieve defined levels of performance, including reliability, safety and availability. 4.33 (2003) An economic assessment considering all agreed projected significant and relevant cost flows over a period of analysis expressed in monetary value. Where the term uses initial capital letters it can be defined as the present value of the total cost of an asset over the period of analysis. It is implicit that the projected costs are to achieve defined levels of performance, including reliability, safety and availability 3.1.12 (2004) An economic assessment considering all agreed projected significant and relevant cost flows over a period of analysis expressed in monetary value. The projected costs are those needed to achieve defined levels of performance, including reliability, safety and availability *Actually, the above WLC definitions 2002 and forward are for life cycle or whole life costing (analysing technique), not for the cost (money).*	
life cycle costing **(whole life costing)**		10.3 a technique which enables comparative cost assessments to be made over a specified period of time, taking into account all relevant economic factors both in terms of initial capital costs and future operational costs	*(Surprisingly, there is no definition for life cycle or whole life costing her at all. Yet, in the intro 2004 it is written: Whole Life Costing (WLC) is a valuable technique that is used to assist in assessing the cost performance of constructed assets. The definition of constructed assets includes all building types and engineering, both existing and new. It is*	*a technique which enables comparative cost assessments to be made over a specified period of time, taking into account all relevant economic factors both in terms of initial capital costs and future operational costs. In particular, it is an economic assessment considering all projected relevant cost flows over a period of analysis expressed in monetary*

			used as a tool to facilitate choices where there are alternative means of achieving the client's objectives and where those alternatives differ not only in their initial costs, but also in their subsequent operational and life care costs.)	*value. Where the term uses initial capital letters it can be defined as the present value of the total cost of an asset over the period of analysis.* [<=ISO15686-1, ISO/DIS/DRAFT15686-5]
period of analysis			4.23 (2001) The length of time over which an investment is analysed. 3.3.2 (2004) The length of time over which an investment is analysed and which may be shorter than the life cycle of the asset	

Both ISO/DIS15686-5 and my definition mean that life cycle is any cycle of life (0...100%), period of time, period of analysis, among which the whole life (100%) is an important (the most important) cycle.

6 Issues under discussion

In the following some ISO15686 related issues under international and Finnish national discussion are elaborated. Some of them are serious disagreements, some others minor problems and observations.

6.1 LCC vs WLC

As said earlier, originally ISO15686-5 was titled "Part 5: Life cycle costing (LCC)", as written in the umbrella standard. Unfortunately the preparatory work has produced totally confusing, derailed papers in contradiction with the umbrella standard. The confusion lingers about the introduction of Whole Life Cost(ing) – WLC, a British wording, to replace internationally recognised Life Cycle Cost(ing) – LCC (the work is headed by British Standards Institution - BSI). Also the arithmetics used diverts from commonly known and understood formulas. This all is to alienate the prospective users from the new standards.

This confusion is well documented in the letter this writer sent to the ISO persons concerned in May 2003, as repeated below.

ISO/DIS 15686-5 Buildings and constructed assets – Service life planning – Part 5: Life cycle costing (LCC) or Whole life costing (WLC)
MY COMMENT ON LCC vs WLC

Olavi TUPAMÄKI
Brussels 22 May 2003

1 Intro

In the past seven years I have been working on sustainable development topics in their economic, environmental and societal domains. In particular, I have concentrated on sustainable development related to the Construction and Real Estate Cluster – CREC, ie sustainable construction. I am a member of several groups in Finland and at the EU level working on sustainable construction; pto.

In this work I have become aware about the welcome development of the ISO 15686 standards, yet concerned about what is happening in the work related to ISO 15686-5. In this paper I want to draw your attention to one single point: that is the use and definitions of LCC and/or WLC. This paper is based mainly on the draft standard ISO/DIS 15686-5 Buildings and constructed assets – Service life planning – Part 5 dated 03 Feb 2003 and partly on its earlier versions and BRE Digest 452 Nov 2000.

2 LCC is known worldwide

It is an undeniable fact that LCC is known worldwide for life cycle costs and life cycle costing. This is easy to see eg by reading through the 400 papers from 45 countries presented in Sustainable Building 2002 conference 22-25 Sep 2002 Oslo NO. A claim that LCC "…is now less commonly applied…" is simply not true. In reality, WLC is mostly known in the UK only!

3 Definitions must be clear

ISO/DIS 15686-5: Introduction says that "…definitions and cost structures must be clear and comparable." So be it.

In the umbrella standard ISO 15686-1 Buildings and constructed assets – Service life planning – Part 1 – General principles LCC is clearly defined:

> ***3.7.5***
> ***life cycle cost***
> *total cost of a building or its parts throughout its life, including the costs of planning, design, acquisition, operations, maintenance and disposal, less any residual value.*
>
> ***10.3 Life cycle costing (LCC)***
> *Life cycle costing (also known as whole-life or through-life costing) is a technique which enables comparative cost assessments to be made over a specified period of time, taking into account all relevant economic factors both in terms of initial capital costs and future operational costs.*

The daughter standards ISO 15686-2…8 should conform to the terms and definitions of the mother standard ISO 15686-1!

4 ISO/DIS 15686-5 is very confusing

ISO/DIS 15686-5: 2 Context says:

"Whole life costing is a broad term, which covers a wide range of analysis, and includes within it several alternative terms which may be more familiar, such as life cycle costing, through life costing and lifetime costing. Sometimes all the terms are used interchangeably but generally the latter phrases are more narrowly interpreted. Typically through life cost or lifetime cost covers the life cycle of the asset from acquisition to start of the disposal phase (excluding disposal and/or replacement)."

Also "…life cycle cost is more frequently used to describe a limited analysis of a few of the components within a constructed asset, rather than the whole building or structure."

The aforesaid and the expression Whole Life Cost itself imply that WLC is for the whole life of a building or other constructed asset, and then LCC would be more for limited analysis and/or for shorter life cycles only; this interpretation is also supported by Figure 1. Yet, in reality LCC covers everything as already said in the umbrella standard! And, yes, LCC definitely is more familiar.

And finally: "In this standard the term used is whole life costs, but it is important to be aware that not all users will be currently using the scope and definitions indicated in this Part." This is confessing the weakness of the draft.

In this draft standard WLC is defined as follows:

> ***4.33***
> ***whole life cost ⇨ life cycle cost***
> *an economic assessment considering all agreed projected significant and relevant cost flows over a period of analysis expressed in monetary value. Where the term uses initial capital*

letters it can be defined as the present value of the total cost of an asset over the period of analysis. It is implicit that the projected costs are to achieve defined levels of performance, including reliability, safety and availability

In reality, this is exactly the definition of LCC, now in a more elaborated mode; hence the red arrow and text above.

LCC appears in the list of 5 Symbols, actually referring back to the umbrella standard definition. Yet, the draft wants to use WLC for all kind of life cycles; long and short, limited and comprehensive. This is double confusing, because the draft first makes you believe that WLC really is for the whole life and LCC for limited and/or shorter life cycles.

5 Conclusion

There seems to be no reason whatsoever to use WLC. It only blurs the picture and makes the stakeholders reluctant to use LCC approach and tools. ***Just drop WLC and use LCC instead, just as it has been globally used!***

(Sign)

List of my memberships; bodies directly related to this paper are highlighted in yellow:

Body	**Under which organisation**
• The Construction Contact Point – CCP	The European Commission - DG Enterprise
• Forum in the European Parliament for Construction – FOCOPE	The European Parliament
• Tripartite Group (Member States + Industry + the European Commission)	The European Commission - DG Enterprise
• CEN-STAR (Committee for Standardization and Research)	CEN - Comité Européen de Normalisation
• CEN-NorBUILD (The Construction Sector Forum for Normative Research)	CEN - Comité Européen de Normalisation
• Working Group "Sustainable Construction"	The European Commission - DG Enterprise
• Task Group TG4 "Draw up recommendations and guidelines on the Life Cycle Costing (LCC) of construction aimed at improving the sustainability of the built environment"	The European Commission - DG Enterprise
• ECCE R&D Task Force (chairman)	European Council of Civil Engineers - ECCE
• CIB W105 "Life Time Engineering in Construction"	CIB - International Council for Research and Innovation in Building and Construction
• ISO TC 59 accredited Finnish Mirror Group	The Confederation of Finnish Construction Industries RT
• Nordic LCC for Construction (LCC för byggverk); Finnish Expert Group	VTT - Technical Research Centre of Finland

Circulation:

- *ISO TC 59/SC 14 Design life – BSI/BRE (15686-5 general)*
- *ISO TC 59/SC 14 Design life – DS (15686 terminology)*
- *EC DG Enterprise's task group TG4: members*
- *ISO TC 59 Finnish Mirror Group: members*
- *Nordic LCC for Construction (LCC för byggverk); Finnish Expert Group members*

Unfortunately, still at that time Finland was not actively participating in the related development work. In summer 2003 Matti J VIRTANEN of Finnish Ministry of Environment, was appointed as a member of the ISO15686-5 international expert group to formulate/finalise the DIS version.

Later these opinions gained a lot of support, not only in Finland but several other countries, too. Finland has been against the various drafts of Part 5 and requires its total rewriting (eg 04 May 2004: "... not in favour of sending 15686-5 to DIS Enquiry" and "Delete all references to whole life costing.").

In September 2004 Finland, under the partial supervision of RT's Finnish Mirror Group, prepared a revised full text for ISO15686-5.

These efforts, however, didn't have much influence on the ISO/DIS15686-5 latest version, as described earlier under 5.3. This version became under international voting, which closed 12 Oct 2004. Voting results by P-members are as follows: 6 approvals, 2 approvals with comments, 3 disapprovals by Nordic countries Finland, Sweden and Norway, and 5 abstentions, as the following figure shows in details.

Country	Member	Participation	Voted
Australia	SAI	P Member	Abstention
Austria	ON		Approval
Belgium	IBN	P Member	Abstention
Brazil	ABNT	P Member	Abstention
Canada	SCC	P Member	Abstention
China	SAC	P Member	Approval
Finland	SFS	P Member	Disapproval
France	AFNOR	P Member	Approval with comments
Israel	SII		Abstention
Italy	UNI	P Member	
Japan	JISC	P Member	Abstention
Korea, Republic of	KATS	P Member	Approval
Malaysia	DSM	P Member	Approval
New Zealand	SNZ	P Member	Approval
Norway	SN	P Member	Disapproval
Russian Federation	GOST R		Approval
Spain	AENOR		Approval
Sweden	SIS	P Member	Disapproval
Switzerland	SNV	P Member	Approval with comments
United Kingdom	BSI	Secretariat	Approval
USA	ANSI	P Member	Approval

Figure 7 ISO/DIS15686-5 Ballot; voting results

In April 2005 several ISO TC59/SC14 meetings took place in Lyon FR. Finland was now present with a strong team.

At this writing, I am not aware about the outcome.

6.2 What life, what cycle?

Already above under 5.4 several important, "fundamental" terms were presented in comparison, as borrowed from related ISO standards. The comparison shows differences and contradictions, which should be corrected in the ongoing development work of ISO15686 series.

Also were presented my own suggestions for definitions, which are in conformance with ISO15686 and harmonised & compatible between themselves. It looks important to define separately life cycle cost (money) and life cycle costing (analysing technique/methods), as actually in ISO15686-1 already has been done. In these definitions I tried to follow ISO15686 different existing expressions and wordings. These definitions I proposed in March 2005 to RT's Finnish Mirror Group and to ISO as well.

Both ISO/DIS15686-5 and my definition mean that life cycle is any cycle of life (0...100%), period of time, period of analysis, among which the whole life (100%) is an important (the most important) cycle.

6.2.1 My harmonised definitions

As there appears to be disagreement within Finnish experts about the meaning of "life cycle", I want to return to this minor but interesting issue one more time. In the following table I show the three "fundamental" terms once again. Now I add reasoning and logic behind my definitions plus add still better and streamlined versions where applicable.

Term	**OT's suggestions, March 2005**	***OT's streamlined suggestions, April 2005***	***Reasoning***
life cycle (lc)	period of time between a selected date and the cut-off year or last year, over which the criteria (eg costs) relating to a decision or alternative under study is assessed. This period may be determined for the analysis (eg to match the period of ownership) or on the basis of the probable	*period of time between a selected date and the cut-off date, over which the criteria (eg costs) relating to a decision or alternative under study is assessed. This period may be determined for the analysis (eg to match the period of tenancy or ownership) or up to the end of the*	*Oxford Advanced Dictionary:* *Cycle = series of events taking place in a regularly repeated order* *Life = period between birth and death, or between birth and the present or between the present and death* *Life cycle = progression through*

	physical life of the asset itself. [<= ISO/DIS15686-5]	*life of the asset.* [improved and streamlined]	*different stages of development* *WSOY Suursanakirja:* *Cycle = sykli, ajanjakso (circle = ympyrä!)* *Life = elämä, elinaika, kestoaika* *Life cycle = elinkaari* ***LCC leads to period of time:*** *Eventually, LCC is calculated as a present value of the accumulated future costs (C) over a period of analysis (t), eg 25 years (N), at an agreed discount rate (d), eg 2% (= 0.02) pa, as shown in the following formula:* $NPV = \sum_{t=0}^{N} \frac{C_t}{(1+d)^t}$ *In this mathematical formula the life cycle is a period of time/ analysis, and this period can be whatever between 0...100%.* *Analogously & inevitably, life cycle is any period of time 0...100%, not only the whole life from cradle to grave/recycle (100%).*
life cycle cost (lcc)	total cost of a building or its parts over a period of analysis or up to the end of its life, including the costs of planning, design, acquisition, operations, maintenance and disposal, less any residual value [<=ISO15686-1, ISO/DRAFT15686-5]	*total cost of a building or its parts over a period of analysis or up to the end of its life, including the costs of planning, design, acquisition, operations, maintenance and disposal, less any residual value* [no need to streamline]	*It is important to define separately life cycle cost (money) and life cycle costing (analysing technique).* *This is a total of (real or nominal) costs accumulated over the life cycle, ie the period of analysis.*
life cycle costing (LCC)	a technique which enables comparative cost assessments to be made over a specified period of time, taking into account all relevant economic factors both in terms of initial capital costs and future operational costs. In particular, it is an economic assessment considering all projected relevant cost flows over a period of analysis expressed in monetary value. Where the term uses initial capital letters it can be defined as the present value of the total cost of an asset over the period of analysis. [<=ISO15686-1, ISO/DIS/DRAFT15686-5]	*a technique which enables comparative cost assessments to be made over a period of analysis, taking into account all relevant economic factors both in terms of initial capital costs and future operational costs. Where the term uses initial capital letters it can be defined as the present value of the total cost of an asset over the period of analysis.* [shortened and streamlined]	*It is important to define separately life cycle cost (money) and life cycle costing (analysing technique).* *This is a technique utilising mathematical methods for economic cost assessment over a life cycle, ie the period of analysis.* *There are several mathematical models, as described eg in ISO/DIS15686-5. While Present Value (PV) and/or Net Present Value (NPV) are the most widely used methods, it looks reasonable to define LCC as such, as it was done in the earlier versions of ISO/DIS15686-5.*

			Eventually, LCC is calculated as a present value of the accumulated future costs (C) over a period of analysis (t), eg 25 years (N), at an agreed discount rate (d), eg 2% (= 0.02) pa dependant on prevailing interest and inflation rates, as shown in the following formula (I prefer to use net present value - NPV , which is more commonly known expression): $$NPV = \sum_{t=0}^{N} \frac{C_t}{(1+d)^t}$$ *In this mathematical formula the life cycle is a period of time/ analysis, and this period can be whatever between 0...100%.* *Analogously & inevitably, life cycle is any period of time 0...100%, not only the whole life from cradle to grave/recycle (100%).* *In case we don't accept this we should start talking about "cycle costing", "periodic costing", "part life costing" or similar. The mathematical formulas we cannot change.*

WLC makes the things even worse; whole life obviously means the whole life of a building, yet now it is intended to cover any period of time. And, at the same time, ISO/DIS15686-5 claims that lcc/LCC are for shorter periods of time only!

6.2.2 Weaknesses in the Finnish revision

The Finnish revision of ISO15686-5 implies that life cycle is only for the full life of an asset, and that LCC calculations also should be made for the same only. This has created a justified comment from the BSI convenor as follows:

> *"There is disagreement about scope (i.e. the dissenting opinion is that the correct term, and scope, is LCC, which excludes revenues, and that it must always cover acquisition to disposal). The scope of WLC was agreed in the second meeting of the working group, and other members of the WG are equally robust in feeling revenues and varying time periods must be covered. The issue of numerous different measures being included in the draft is equally contentious within the working group – but these measures are in daily use in the UK and other countries, and have been standardised within the US for many years. The comments also suggest that only public owners will use LCC – and contrast it with investment analysis techniques generally."*

The points underlined above are serious weaknesses in the Finnish revision (scope in particular, public too; these remained in the Finnish version despite of my strong opposition in the Finnish Mirror Group) as now tactically picked up and correctly pointed out by Kathryn Bourke, the convenor. They cannot be sustained. They also most probably destroy our principal point ie the change of WLC back to LCC and related.

The convenor also proposes a very interesting amendment: "*Make plain that NPV is the most common measure in use internationally.*" This I definitely support.

6.3 What service life?

Already earlier under 4.3 and 5.2 different features of service life have been discussed. As opposed to using simple numerical factors, also other more sophisticated methods can be used, such as eg proposed in the CIB publication 294 above, which incorporates the use of probability density functions for factors as well as for the service life of individual components to arrive at an overall estimate of a building's service life. This probabilistic approach is further developed in a European RTD project ***EuroLifeForm*** (Probabilistic Approach for Predicting Life Cycle Costs and Performance of Buildings and Civil Infrastructure).

6.3.1 EuroLifeForm

For LCC to become widely accepted, concerns about uncertainties in forecasting must be overcome: costs and performance of a building, its components, assemblies and systems, maintenance and management.

An important European RTD project **EuroLifeForm** is to develop a design methodology and supporting data, using a probabilistic approach, with a budget of 3.8 MEUR over 2001…04. Villa Real (FI) is the originator and a major partner, and Taylor Woodrow (GB) the coordinator.

The newest theories and software are used for probability, risk, sensitivity analyses and optimisation (**@Risk 4.5** Industrial using Monte Carlo / Latin Hypercube simulation) and for complex multi-objective/multi-criteria decisions (**Logical Decisions 5.1**). In all seven partner countries data and information is collected; generic and on 11 case studies

A pack of models to enable a lifetime design process utilising the LCCP approach was developed. The under-listed related software tools are now near completion, soon ready for national customisation, commercialisation and consulting services. Visual Basic 6 is utilised to increase versatility, enable integration and to improve user friendliness. The integrated pack and its modules are wiser than the insular deterministic methods currently in use. Thus the name **LCCP Wise™** for the software pack.

- **LCCP GateWise**: A gateway to the other LCCP tools, registries for computation results & decisions made, and database repositories.
- **DB LifeWise**: Database with min/most likely/max reference service life values for building elements (components, services, parts).
- **LCCP LifeWise**: Deterioration model at @Risk & Excel, utilising ISO 15686-1 factor method. It provides estimated service life for replacement, as expected in the particular project on hand, plus data for planned preventive maintenance and reactive maintenance, all in a probabilistic format. Integrated with LCCP AllWise.
- **DB CostWise**: Database with min/most likely/max cost values for building elements (components, services, parts). Usually this data is highly commercially sensitive, kept secret and not available for the public. Contractors, quantity surveyors etc can use their own data.
- **LCCP AllWise**: A calculator at 3 levels, Client brief, Concept design and Detailed design based on @Risk, most important.
- **LCCP EnvWise**: Excel-based screener to assess environmental impact.

Actually, all these tools would be directly related to the series of ISO15686 standards. Here I only further explain some findings concerning service life; data availability and the probabilistic properties of service life. This approach is supported by ISO15686 and the two CIB reports described earlier under 4.3.

6.3.2 DB LifeWise

The starting point here is Building Cost Information Service – BCIS & Building Maintenance Information – **BMI** as developed and maintained by The Royal Institution of Chartered Surveyors, GB. This is also referred to in ISO/DIS15686-5. Their data bank contains current, accurate information on UK building costs, tender prices and building maintenance for a wide range of commercial, industrial, residential and public sector buildings. BCIS is for capital cost information while BMI covers maintenance management information and building maintenance, property occupancy and refurbishment costs for 125 elements. And it gives out reference service life as min/most likely/max type data.

In DB LifeWise, the classification of elements and subelements is as per BCIS/BMI. Additional subelements can be added as needed (and they are needed as structures/constructions in different countries are really different). The related UK min/most likely/max performance values (years) are presented. In each country the values may be different, dependant on climatic and other agents.

For performance/deterioration/service life, in Finland we have very little to no data. Yet, the situation is improving. During 2002…03 a project titled "**LifePlan**" was carried out by VTT (see http://pim.vtt.fi/lifeplan/view/). The project aimed at creating a large product-specific data base for service life information of building products and components. The project introduces methods on how to use this information in service life design and in operating buildings. In the LifePlan data base service life is expressed with a single number of years, which value is assumed to be exceeded on 95% probability. Today less than 300 items are in the data base, and its maintenance and future development is unclear.

When you really go to look at the information in details, it is easy to see that the service life values (eg 100 years) are not based on any real knowledge or scientific calculations. Numerous interviews of the manufacturers completed by Villa Real prove that no probabilistic performance data is available, and that the aforesaid LifePlan 95% probability values are the best estimates only! Any min/most likely/max type reference service life values we don't have in Finland

6.3.3 LCCP LifeWise

Min/most likely/max reference service life data utilised; BMI list of elements as a default, new subelements added for a Finnish case study object Next House (here Delphi method was used to create the data by a team of wise persons), any other (sub)elements can be added.

ISO 15686-1 factor method (7 factors) used. Utilises probabilistic approach; Monte Carlo simulation by @Risk. LogNormal distribution as a default; Weibull and others can be used.

Outcome is **min/most likely/max estimated service life** of the particular element concerned, plus probabilistic data for repairs & maintenance.

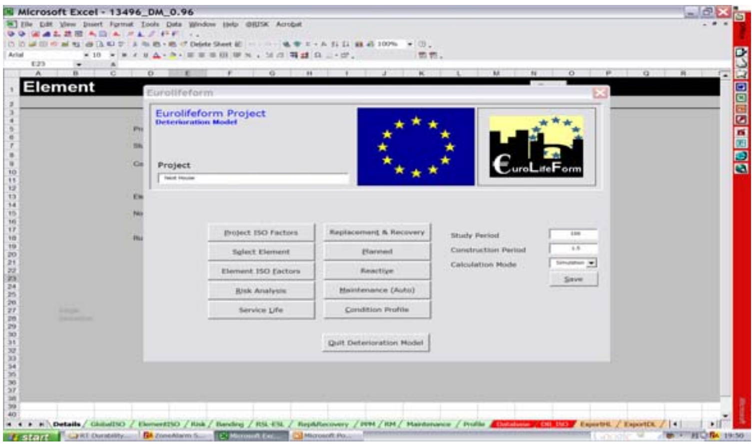

Figure 8 Opening screen of LCCP LifeWise for service life and maintenance estimation

The software is incorporated in the LCCP AllWise, thus the outcome estimated service life and maintenance (ppm & rm) values will be directly observed as input in LCCP computing, again utilising @Risk.

6.4 What discount rate?

6.4.1 As per ISO/DIS15686-5

In the paper, nominal and real discount rates are defined as follows:

Nominal discount rate = rate used to relate present and future money values in comparable terms taking into account the general inflation/deflation rate [as per 3.3.1]

Real discount rate = rate used to relate present and future money values in comparable terms, not taking into account the general or specific inflation in the cost of a particular asset under consideration [as per 3.3.3]

Surprisingly, their mathematical relationship is not properly formulated. Also their optimal use has been left unclear, and their levels fully open. Now, fortunately, the convenor has expressed her willingness to add "*Definitions to make clear where real or nominal discount rates are used.*".

6.4.2 Problems and observations

LCC = NPV calculations should be easy, it is just arithmetics. Yet, after my seven years' research, it appears that the lack of knowledge (note: noise ⇨ data ⇨ information ⇨ knowledge ⇨ wisdom) and misconception are prevalent within the decision-makers and experts alike, as well as the various CREC stakeholders. Some examples follow, mainly concerning Public Private Partnership - **PPP projects** funded by tax payers' money:

- **Wide variation** on the discount rates used; in EU25/10a: 2...12% pa.
- **Constant discount rates** used unchanged for years, although the actual rates have fluctuated >50%; eg the UK 6% pa.
- Generally **too high discount rates** used, which makes future costs/ savings meaningless; In EU11/10a: interest rate i=3%, general inflation a=2% ⇨ discount rate d_{real}=0.98%. In EU25/20a: d_{real}<0% in several years. In Finland today a family house mortgage: i=3.7% (5a fixed) / 3.3% (weighted average), a=0.8% ⇨ d_{real}=2.88 / 2.48%].
- Real (ie today's) discount rate used together with nominal (ie future) costs; **wrong formula** leads to wrong/meaningless results.
- Nominal discount rate used together with real costs; **wrong formula** leads to wrong/ meaningless results.
- In some PPP project invitation documents (eg in the UK) the client has left **the discount rate open**. Thus the tenderer must present their own discount rate as part of their tender; here the tenderer may take an additional calculated risk (probabilistics with different scenarios and sensitivity analyses help). To avoid major failures, here all stakeholders must thoroughly understand the concept the same correct way.

6.4.3 Discount rate is important

- For any long-term (investment) calculation discount rate is necessary. Simple payback is too crude, and too high discount rate nullifies the future costs/savings. Thus a **correct discount rate** must be used.
- For any professional investor the use of **discount rate is a must**. The rate used depends on the return of investment required/expected.
- In sensitivity analyses discount rate is often one of the most **sensitive** determinants.
- For PPP projects real discount rate and real costs should be used. For the good of society and to avoid escalating future operating costs, optimally **d_{real}= 1...2% pa** in the today's EU11 economic environment.

- A winner can be always selected at whatever predetermined discount rate, yet the eventual outcome may be disastrous for the stakeholders and society! Particularly so, if too high d_{real} or wrong formulas are used.

6.4.4 What discount rate for what economies?

The net present value - NPV of accumulated future costs depends on the used discount rate(s). In the following chart I introduce four "rooms" of different stakeholders. For each room a certain level of nominal discount rate is applicable, dependant on the return of investment required/expected by the particular stakeholder.

These rooms I descriptively call **Natural** (d=0% = simple payback), **National** (3%), **State** (6%) and **Business** (9%) Economies. The chart shows how NPV is accumulating over 1…25 years in each room/ economy at their respective nominal discount rates.

In addition, I offer 1% pa as a suitable real discount rate for public works.

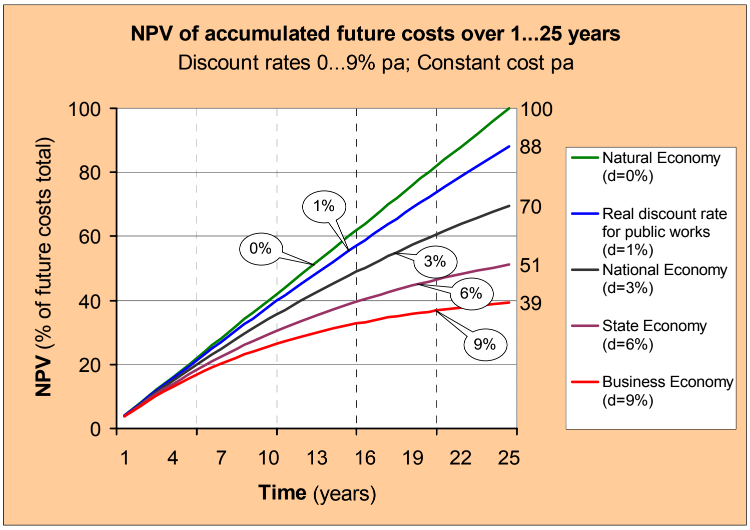

Figure 9 NPV of accumulated future costs in different economies

The actual rate of return available through LCC considerations on the operating costs of buildings and other constructed assets today may be lower than that offered by alternative long-term investment: as a nominal annual rate of return, stock market 15% (-90% for .coms ⇦ risk), 9% business ROC/ROE (⇦ risk), 6% bonds, 3% bank deposits.

Yet, buildings, roads, bridges and other constructed assets have long service lives. At low discount rates long-term future costs and savings are immediately meaningful, as can be seen in the above figure at 1% rate. Then investment for the better future looks more rewarding.

Also, it can be claimed that future operating costs will be increasing due to higher energy prices and new environmental and other regulatory requirements. This development will raise the calculated return in Euros or Dollars and may enable market-driven LCC considerations.

And, often the investment for lower operating (eg energy) costs is only marginally higher than for a "standard" design.

7 Conclusions & recommendations

- Internationally recognised standards and practices should be developed; ISO, CEN. This is particularly true for the EU15 and the whole EU25 to fulfil the objectives of the open internal market.
- Discrepancies appearing in the development work of ISO15686 should be amicably solved.
- The value of the LCC calculations should be made better understood, including the role of suitable discount rates.
- New methods should be developed for the ease of understanding and application. Monetary values in Euros or Dollars are easy to understand instead of different ratings, scorings and points.

- For LCC and other life cycle techniques to become widely accepted, concerns about uncertainties in forecasting must be overcome: (1) costs and (2) performance of a building or another constructed asset; its components, assemblies and systems, maintenance and management over its life.

8 Bibliography

1 ISO15686-1 Buildings and constructed assets - Service life planning - General principles, ISO 2000, 52p (plus background)

2 ISO/DIS15686-5 Buildings and constructed assets - Service life planning – Life Cycle / Whole Life Costing, various versions, ISO 2001…05, 270p (plus background)

3 ISO/DIS 15686-5: Finnish version, 2004, 25p

4 ISO/CD15392 Sustainability in building construction/ General Principles, ISO 2004/05, 20p

5 An Agenda for Sustainable Construction in Europe, EC 2001, 69p

6 Life cycle costs in Construction, EC 2003/04, 96p

7 Toward a thematic strategy on the urban environment, EC 2004, 56p

8 CEN/BT WG 174 Integrated environmental performance of buildings, Afnor 2005, 16p

9 LCC for byggverk - Nordisk hovedprosjekt – slutrapport, SBi 2005, 50p

10 Sustainable Building 2002, CIB, iiSBE, NBI 2002, 417p

11 Performance Based Methods for Service Life Prediction - State of the Art Reports, CIB 2004, 107p

12 Guide and Bibliography to Service Life and Durability Research for Building Materials and Components, CIB 2004, 377p

13 Construction Can!, Olavi Tupamäki 1998, 58p