LCC-REFURB

LCC-IP GUIDEBOOK

Integrated Planning for Building Refurbishment

Taking Life-Cycle-Costs into Account

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A great deal of additional information on the European Union is available on internet.
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Content

1 Introduction

The technical requirements to modern buildings are constantly rising, simultaneously the economic pressure on building owners – public and private ones – is increasing as well. Besides these economical framework conditions the European Union promotes the development of sustainable buildings targeting at reducing the ecological impact of the building stock.

Sustainable buildings take aim at the minimisation of energy consumption, consumption of resources during all phases of the life span of a building. These phases are planning, construction, operation, renovation and demolition. Other environmental and social issues, human health and well-being are also taken into consideration.

In order to achieve these goals and to optimise the total costs during the life-cycle of buildings, instruments like Integrated Planning and Life-Cycle-Cost-Analysis (LCCA) need to be established during the planning process for new constructions and for building refurbishment as well.

The Life-Cycle-Cost-Analysis takes the investment costs and operational costs (e.g. energy, maintenance, cleaning) of all phases into consideration. As the operational costs make up the main part of the total costs over the whole lifetime of a building, the comparison of the life-cycle-costs of different scenarios creates the necessary (cost) transparency for the decision-making process.

Based on the results of a LCCA the building owners and planners are able to optimise the over-all performance of a building and they are able to make founded decisions for the further process.

This guideline gives an overview on integrated planning and on the application of LCCA for building refurbishment. It informs about:

- Integrated planning
- Applying LCCA and integrated planning in refurbishment process
- Best practice examples

Furthermore, it contains addresses for and links to further information about integrated planning and LCCA.

2 Integrated Planning

The great complexity of today's building construction or refurbishment processes requires a high level of integration in the planning process. Common planning strategies, where individual project partners cooperate mainly by exchanging results, are not suitable to jointly develop project goals and objectives. Integrated Planning, a more holistic approach to deal with complex problems, is based on:

- an overall approach, simultaneously integration of technical, financial, environmental and social criteria,
- a high degree of communication among team members,
- a long term approach taking the whole life-cycle of a building into account, including construction, operation, refurbishment and destruction.

The multidisciplinary approach, an extensive time scale as well as the diversity of the players involved make Integrated Planning necessary in building construction or refurbishment processes.

2.1 Integrated Planning in New Construction

Although integrated planning can be applied all along the building construction process, it has a major effect during the design stage.

Integrated building design is a process of design in which multiple disciplines and seemingly unrelated aspects of design are integrated in a manner that makes synergistic benefits possible. The goal is the achievement of high performance and multiple benefits at a lower cost than if all the measurements are undertaken the total for all the components combined separately.

Integrated building design is most effective if key issues are addressed early in the facility planning and design process. Opportunities can be most easily identified through an open process of investigating how to combine low-energy use and other sustainable strategies in order to achieve the best results.

Figure 2.1 suggests that the design integration becomes a part of the process, the earlier the more successful the results are. Conversely, if a building is designed "as usual" and later sustainable technologies are applied to it as an afterthought, the results will probably be poorly integrated into the overall building design objectives and the sustainable strategies will likely be expensive to implement.

2.2 Integrated Planning in Existing Buildings

Many non-residential buildings such as offices, administration buildings or schools, which were built between 1950 and 1980 require to be refurbished.

The investment costs for the refurbishment and for the maintenance of buildings contribute significantly to the total cost of a building over its lifetime. For example, for a building service life of 100 years, the maintenance costs account for 80 to 85% of total expenditure, whereas design and construction costs account only for 15 to 20% throughout the building service life.

There is a growing awareness that unplanned maintenance and refurbishment costs may amount to half of all money spent on existing buildings. Integrated Planning could reduce operation and maintenance costs of buildings.

The prevailing refurbishment practice, however, represents a major obstacle for the implementation of technologies that are innovative, ecological compatible and/or reducing operating costs. That is because the costs of construction is still considered as the all-dominant factor, whereas the operating costs and a possible loss of value of the building due to lacking qualities are not taken into account and they are still playing a subordinate role.

Integrated Planning of the refurbishment process enables an economic optimisation in terms of the whole life-cycle-costs of the building. Furthermore, it is possible to contribute directly to the achievement of sustainable built environment through including additional quality criteria such as indoor air quality, sound insulation or ecological quality of the building materials.

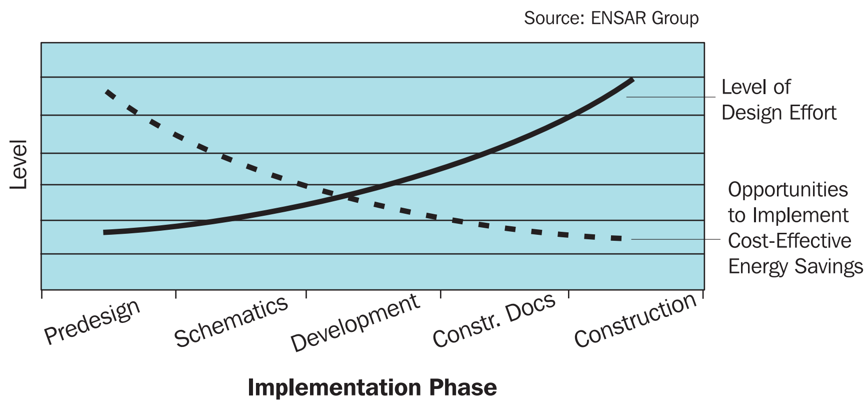


Figure 2.1 – Design process

2.3 Refurbishment Process Management

Figure 2.2 describes the different steps in a refurbishment process: diagnosis, brief, design, construction and the operation of the refurbished building.

All along the refurbishment process, integrated planning has to deal with various criteria that can be divided into two categories:

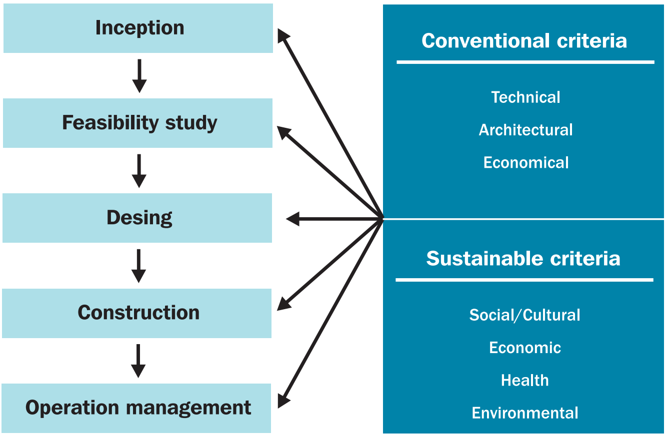


Figure 2.2 - Five steps of a refurbishment process

Conventional criteria:

- Architectural (organisation of spaces, aesthetics, functionality, flexibility)
- Technical (law, regulation and standards, safety, durability, performance, maintenance)
- Economical (investment cost, operation and maintenance costs, life-cycle costs)

Sustainable criteria:

- Environmental protection (rational use of natural resources, reduction of air and water pollution, reduction of nuisance during the construction phase)
- Human health and well-being (hygro-thermal, acoustic and visual comfort, indoor air and water quality)
- Economic life and cultural concerns

The following section describes every step of the refurbishment process and figures present the specific tools, actions, actors involved, results and decisions.

2.3.1 Inception

In order to prepare and to plan a good refurbishment project it is important that all conditions are mapped and investigated before forming the project (see figure 2.3). The inception delivers the basis information for further decisions. Many analyses such as socio-urban, economic, technical or environmental ones are performed. The different analyses are helping to identify problem sources and causes. Furthermore the analyses provide the description of the initial state of the built area structured according to sustainable and conventional criteria. The result of this stage is a structured list of items that need to be studied through feasibility studies. Especially when talking about refurbishment project feasibility studies should be carried out in various stages. To achieve best reasonable result those studies should be carried out on life cycle cost basis.

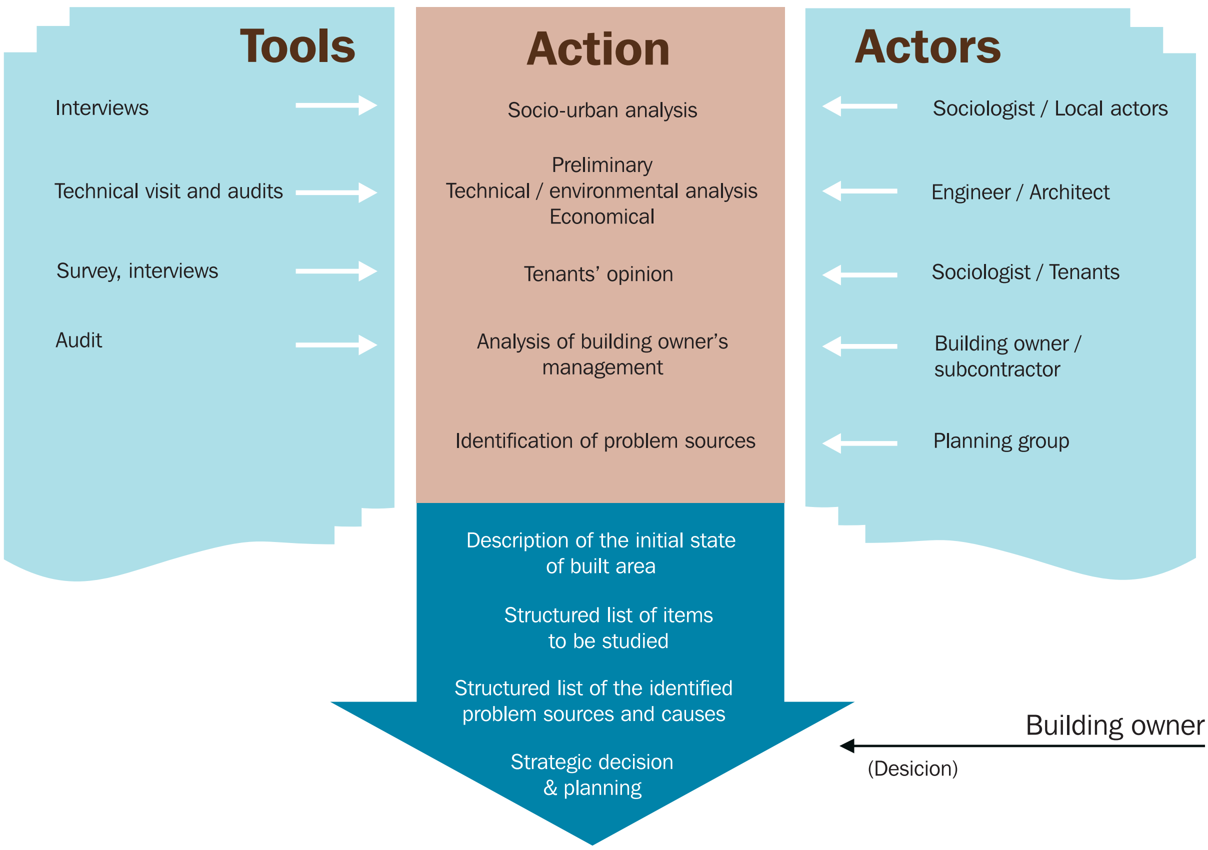


Figure 2.3 – Inception

At this stage the decision maker has the choice to:

- invest in the next phase
- delay investment
- abandon the project

There is a need for to begin a refurbishment project. Whether there are some technical appliances at the end of their service life, there is a need to improve the working conditions of the tenants or the building just needs a facelift the building owner has to decide to start the process.

Present tenants and maintenance personnel should be interviewed to find out the actual stage of the working performance of the building. At this stage the interviews do not have to be too detailed as the main reason for doing these is to gain basis for starting the renovation.

Some preliminary condition assessments are carried out or previously made analysed if they exist and are not more than five years old. These assessments are light, only like a walk-through taking couple of hours to one day to carry out and prepare a report. The condition assessments could be done by building owners own personnel but in most cases it is worthwhile to have an external opinion.

It is the good idea to hire first engineers or consults for the refurbishment project at this point. The commitment and the final results are much better if the project team construction start at the very first stage of the project. This is especially important in refurbishment process as there are most building components already existing and communication throughout the whole project is vital.

2.3.2 Feasibility Study

The results of the inception have to be investigated and feasibility studies (LCCA) have to be performed as preparation for the feasibility study. Life cycle cost assessment is quite preliminary at this stage. It becomes more and more detailed as the project continues. In the feasibility study, clients' needs and requirements are translated into an overall sketch design, which incorporates the layout and construction methods of the building (see figure 2.4). These studies have to be relatively flexible in order to give sufficient freedom to the architects, designers and other advisors. The results of measurements and investigations done during the inception phase should be incorporated in the brief. The feasibility study will be adapted during the design phase, because it is not possible to study all opportunities and constraints. It is essential that maintenance engineers are involved in the decision making process for the development and implementation of all refurbishment works.

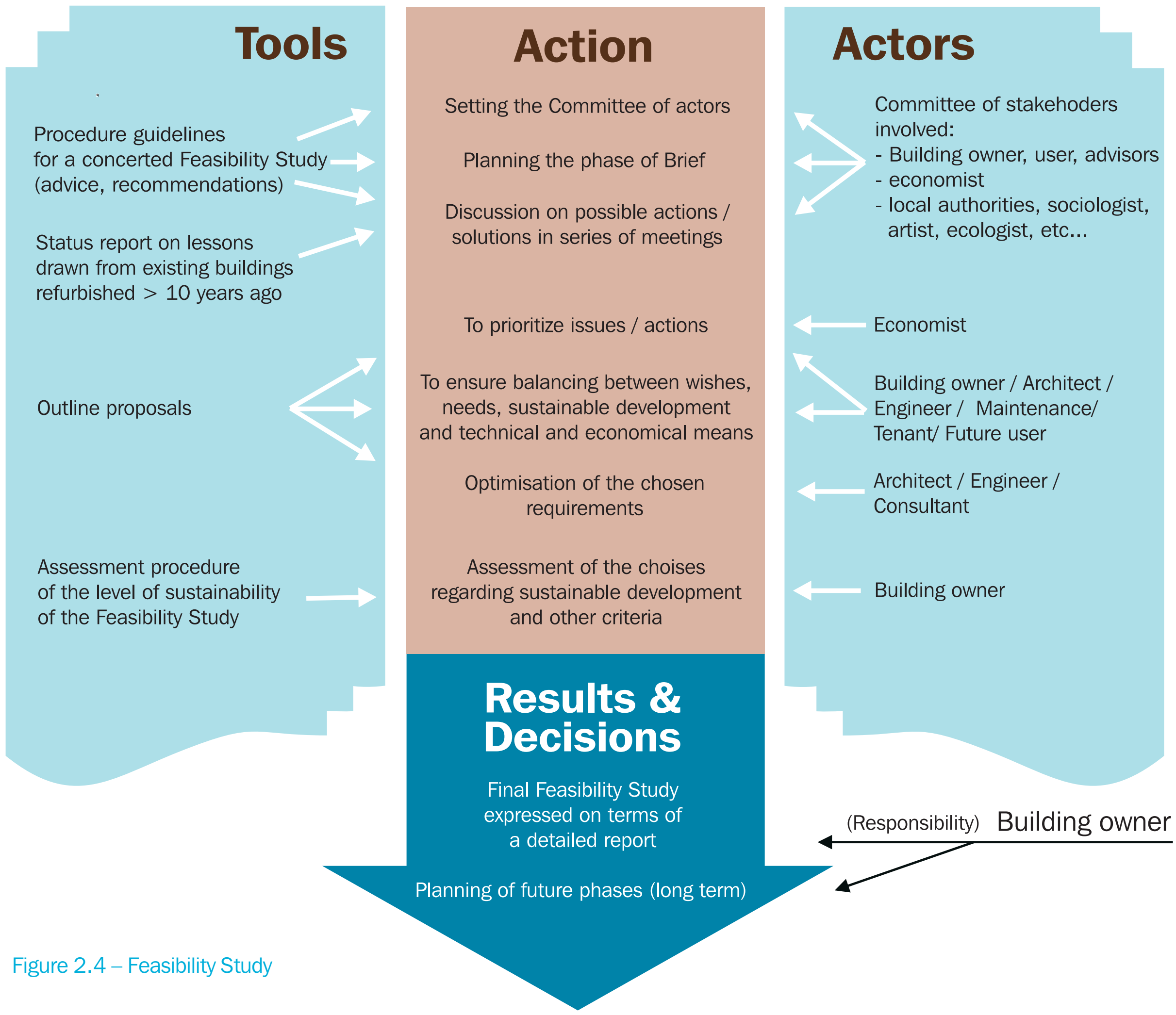


Figure 2.4 – Feasibility Study

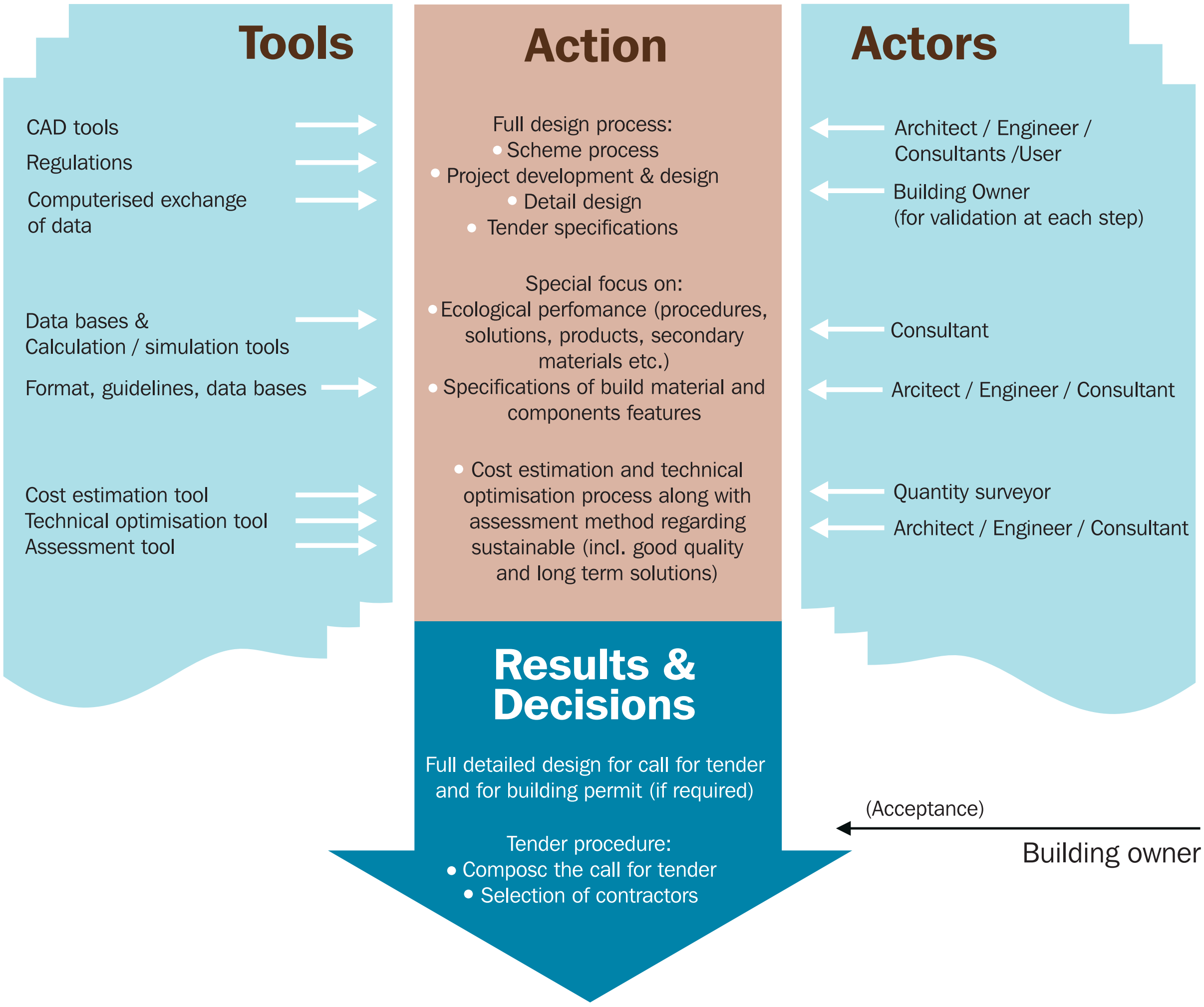


Figure 2.5 – Design

2.3.3 Design

The purpose of the design phase is the creation of a design for every part and component of the building in conjunction with other design stakeholders. Client requirements are translated into functional requirements (functional design). The energy audit and condition inspections are carried out at the beginning of this phase. The need and the comprehensiveness of these assessments is dependent upon the scale of the project. The best design alternative is selected regarding risks and benefits (financial and non-financial). Unresolved decisions are finalised, especially those relating to design specifications, construction methods and associated costs. The design phase includes several sub-phases:

- Scheme design
- Project development & design
- Technical design & specifications
- Design and tender specification
- Tender procedure (compose the call for tender, selection of the contractors) and procurement strategy (which appliances are acquired by project management and which by by contractors)

The results of this phase is a detailed design for the project and for the building permit if needed and the call for tender (see figure 2.5).

It should be noticed that in case of refurbishment in most cases it is not sensible to produce too detailed design for call for tender as there are many uncertainties. When working with existing building there may be some constructional or some hidden components which are unrecognizable during the design phase. In many cases there is a need to do detail design during the construction phase. This is why it is very important to keep the project group and consults involved during the whole process from diagnosis to commissioning and handover.

It is vital for design to succeed that project group and consultants involved visit the building to be refurbished. The number and the duration of visits depends of the comperehensiveness of the project. Before the call for tender is launched an updated narrative review of the previous phase should be conducted to make sure that the initial hypotheses used in the economic analysis and selection process have not changed. There should also be a notice in the call for tender that the tenderer should visit the refurbishment site before he/she sends in the tender for the project. These actions enable that the best available information is gained for successful construction phase.

2.3.4 Construction

The construction phase contains besides the construction itself final detailed design and the preparations for building maintenance manual (see figure 2.6). It is important to re-examine that the designed refurbished building is still meeting the need of clients and their customers. In the construction phase the environmental management system for the operation phase is set up including the specifications on responsibility, organisation, procedures, quality guarantees, ecological quality and performance, implementation, assessment, etc. The phase includes several sub-phases:

- Updating all previous decisions if necessary
- Establishing construction planning
- Selecting construction technology and methods
- Site processes (avoid environmental risks)
- Allocating resources, especially workmanship level and quality of materials
- Detailed design
- Commissioning processes
- Assessment of the construction phase
- Completion and handover

The results of this phase are:

- Contractual arrangements
- Reporting and monitoring mechanisms
- Manual and plans for future operation/ maintenance

2.3.5 Operation

The purpose of this stage is to conduct a post occupation and an operational assessment of the refurbished building (see figure 2.7). The main part of the costs occurs at this stage, if the whole lifetime of the building is considered. Thus careful operational planning and optimisation are required. Maintenance and replacement plans and budgets should be forecasted based on the annual performance of the building.

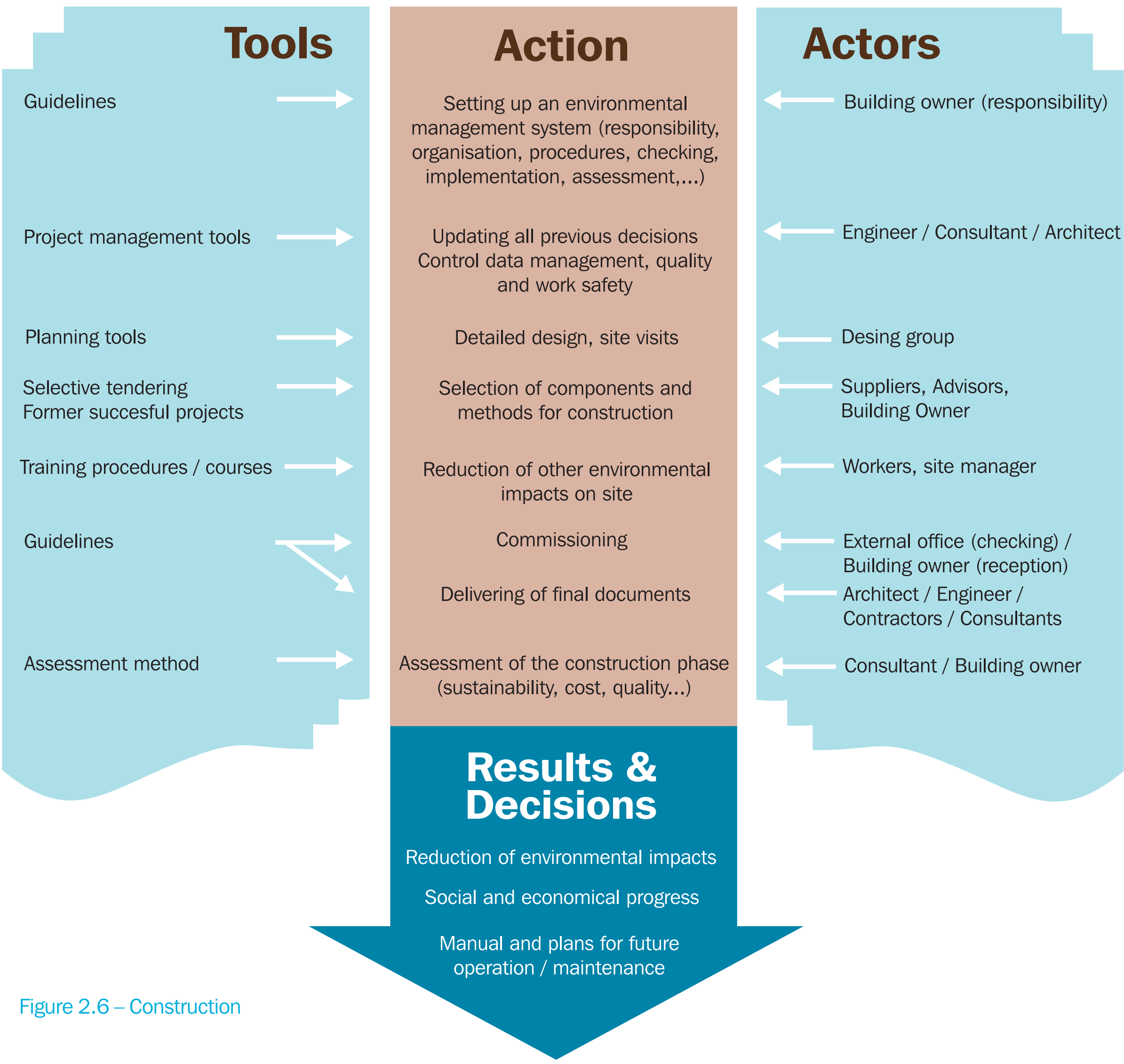


Figure 2.6 – Construction

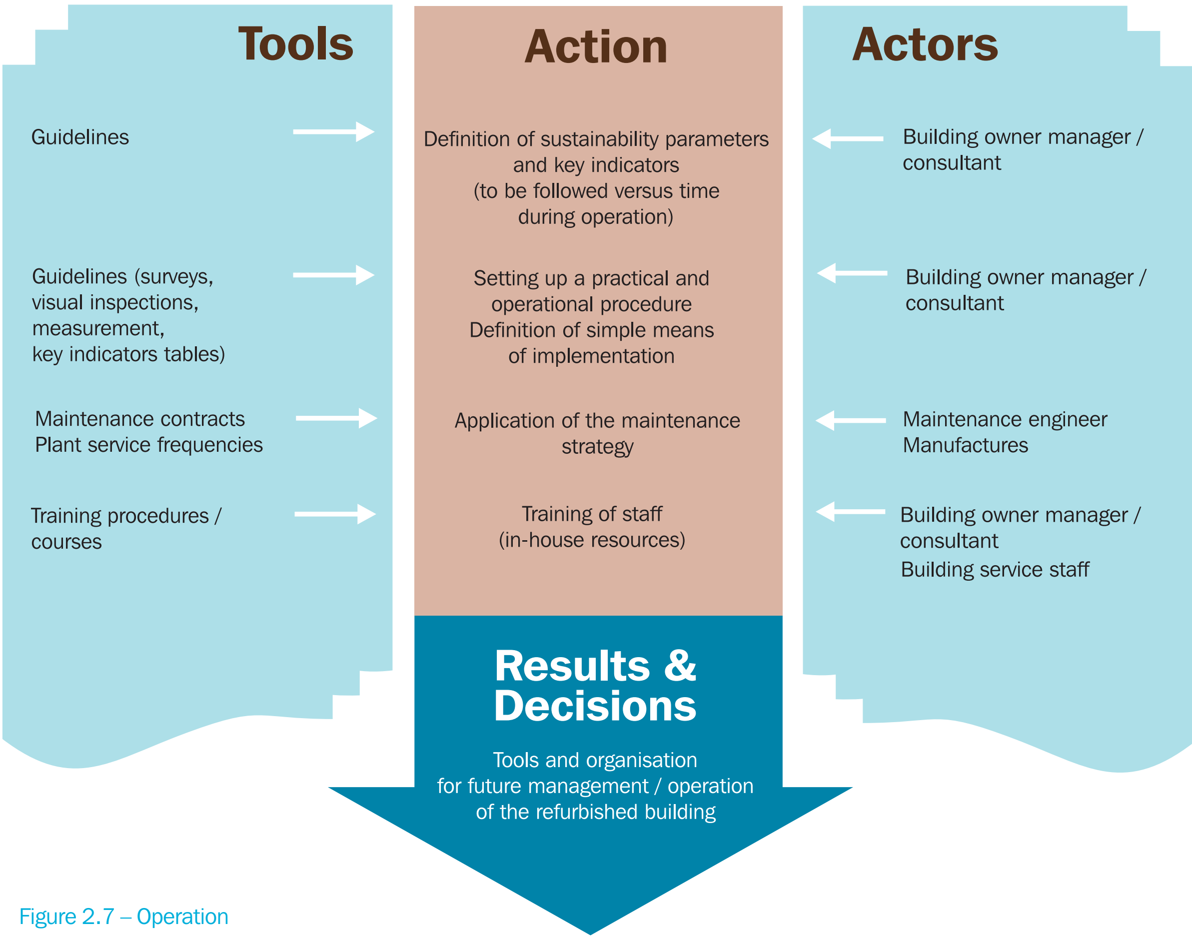


Figure 2.7 – Operation

Once the level of operation and maintenance required to satisfy the building operator objectives is established, it is in the responsibility of the operational management to:

- establish the health and safety policy
- establish the operation and maintenance policy
- develop information system for operation and maintenance
- procure and manage operation and maintenance activities
- set budgets

Operating, maintenance and rehabilitation costs of new and existing facilities amount to more than 80% of the total life-cycle costs. The majority of decisions about these costs are predetermined at the design stage. The opportunities to modify or influence these decisions diminish as projects progress through their natural process of development (see figure 2.1). Hence, risks and consequences of these decisions on the total cost of ownership of assets must be considered and planned. This is why it is important to establish a mechanism that brings together the life-cycle cost, service life and environmental life-cycle assessment. This mechanism is called integrated planning.

3 Applying LCCA and Integrated Planning in Refurbishment Process

3.1 Life-Cycle-Cost-Assessment/Analysis (LCCA)

Life-cycle-costs (LCC) are defined as the total cost of a building or of a specific building component throughout its lifetime, including the costs for planning, design, acquisition, operation, maintenance, demolition and disposal less any residual life. The life-cycle-costs include both investment costs and operational costs, throughout the whole functional lifetime, including demolition. If the building or building component still has a value after the lifetime of interest for the investor, the demolition or disposal costs can be replaced with income from sale of these values.

LCCA can be used for the evaluation of alternative investments for:

- choices among alternative designs
- detailed design
- choices among alternative materials, components and systems
- rebuilding, additions (i.e. vertical additions of one or more stories) or extensions (i.e. horizontal extensions or annexes)
- improved or alternate operation

3.1.1 Boundary Conditions and Time Periods

LCCA can be done for different time periods depending of the perspective of the decision makers. If a shorter time period than the whole lifetime is regarded, the rest value (value of project by end of period chosen) has to be considered. The rest value may be positive or negative.

Some examples:

Installations or product with a long life time may still be usable after the period of interest. If the building should be demolished, some of the products could still be sold instead and hence give an income instead of a cost.

An investor might only be interested in the near future, i.e. 5-10 years. After that time the building might be demolished or sold. Demolishment is a future cost to consider, while if selling the building the value of that time (residual value) is of interest.

3.2 Performance Requirements

Different actors within the building industry are using different definitions and classifications for performance requirements and specifications in e.g. legislation, client briefs, reports and publications. This can obstruct clear communication and exchange of knowledge. One of the challenges in an integrated planning process is the management of user requirements defined as performance requirements throughout all phases of the design process.

The performance requirements for the building are defined by different stakeholders, who may also have opposed requirements. An important task is the translation of client and user requirements into performance requirements (or in order words the matching of user requirements and performance requirements). Clients and users usually communicate in 'user language'. This means that they are not always professionals on technical matters than their work. for instance an office worker would like to have non-draught and even temperature for his/her working place but is unable to specify that there should be high quality air-conditioning with cooling. The translation of this user language into objective, measurable performance requirements and/or specifications requires specialist skills. The result should be a temporary list of performance requirements or functional specification.

Examples of performance requirements:

- Costs – investment and annual cost
- Easy operation and maintenance of technical installations
- Service life
- Area – room for intended purposes
- Indoor climate
- Environmental impact
- Energy use
- Accessibility for all
- Flexibility
- Regulations

Visions and goals for the refurbishment process should be defined by using performance requirements.

3.3 Implementation of Integrated Planning

Clients and future users demand more involvement and influence in the design process. Modern information and communication technology (ICT) tools like internet and virtual reality, the modelling and animation of three-dimensional inhabited virtual worlds, enable them to participate actively in the process. One cannot expect that clients deliver a complete and unchangeable brief before the start of the design process, but instead a framework for the project based on ideas. The design process is also a voyage of discovery for clients and users and they expect the designers to facilitate that voyage. The question arises how to fulfil these demands and at the same time how to improve the efficiency and manageability of the design process and improve the total quality of the building.

Integrated planning demands that more resources are invested into the brief and design phases. The process is depending on whether the building will be used for the same purpose as before the refurbishment or not.

Important actors in Integrated Planning are the different stakeholders: owners, users, design group, maintenance and operation personnel.

3.3.1 Diagnosis and Brief Phase

The project manager involves a planning group composed of different stakeholder. Users (or future users), client/owner and consulting engineers/architects are all important member of the planning group. The user group may include different user as well as personnel responsible for operation and maintenance.

At an early stage it is important to collect all existing information about the building usable for planning and decision making and compare this information with the performance requirements. The interaction between the tasks defined and the necessary adjustments for reaching the goals is important for a good planning process.

Energy Audit

Calculations of the theoretical energy consumption should be done for the existing building and the result should be compared with the actual consumption. Causes for discrepancy should be investigated.

Energy calculations can also be done with proposed actions in order to identify energy saving potential.

Energy use should be benchmarked.

Condition Assessment

In addition to an inspection of the building and of the technical and functional conditions of installations the condition assessment should investigate if and how the performance requirements are fulfilled.

The condition assessment gives information about what is needed or recommended in order to be altered by the refurbishment.

The condition assessment tells also whether there are requirements that will not be fulfilled (partly or totally) after the refurbishment.

Functional Description

Based on the results of the condition assessment a functional or/and technical specification of necessary work may be drafted.

The functional description should also tell whether there are requirements that will not be fulfilled (partly or totally).

Environmental Assessment

An environmental assessment can be used to identify the environmental impact of the building and to find out what could be improved or taken into account during the refurbishment process.

Other Assessments

Based on the motivation for the refurbishment special assessments should be done regarding specific requirements of the stakeholder or requirements based on complaints where applicable (indoor climate, accessibility, new fire regulations, etc.). Methods for such assessment are questionnaires, interviews, inspections, calculations or measurements. Information about how different requirements are fulfilled in the present situation is an important input for decision making and for a comparison between different proposals.

Economical Assessment

Investment costs should be calculated based on functional description and key number. Preliminary LCC calculations based on best available data and key number for existing and future situation should be done.

LCCA should either provide information necessary for a comparison of the total LCC for an existing building compared with the recommended refurbished building or for a comparison between alternative proposals for refurbishment.

LCCA could also be done for selected kind of costs, like individual technical appliance, only indicating the differences between alternatives.

Available funding for investments should be indicated.

Decisions – Framework

At the end of the diagnosis phase decisions have to be made. Should the project stop or continue? If the project continues long term planning of future steps should start. The framework for the further project has to be defined (economy, goals, time frame mandates, etc.).

Important information for decision making is the LCC in regard to how performance requirements are fulfilled. A comparison of qualitative and quantitative information is a challenge in the process.

3.3.2 Design Phase

The design phase includes planning and design and more detailed calculations and simulations. The planning group can be reorganised or new members can be involved. Architects and consulting engineers get more important, but it is important to continue involving the other stakeholders.

Design Process

During the design process it is important to focus on the problem of 'meeting performance requirements'. Different technical solutions should be investigated and feasibility studies (LCCA) may be done. It is important to measure how alternative suggestions meet the performance requirements.

The energy consumption for the alternative suggestions should be calculated.

Environmental assessment and other assessment should be done for the alternative suggestions and facilitate a comparison.

LCCA should be done for the alternative proposals and the results should be compared. Best available data should be provided for the LCCA.

Optimising and Decision Making

The results from the studies and assessments for different suggestions can be compared with each other, with the existing situation and the performance requirements.

Different tools are available for doing multiple criteria decision making.

In the decision making process it is important to involve the planning group, especially in the discussion which criteria should be fulfilled, in case not all criteria can be fulfilled (partly of totally).

The decision making process should give overall recommendations including costs.

Planning Process

The planning process includes more detailed design and planning. Technical solutions and installations are chosen based on the performance requirements.

LCCA should be done on a more detailed level, for instance by comparing materials, products and systems. Calculations should be done with best available information. The LCC results on detailed level should be an “accumulated input” to the total LCCA.

The planning process includes several steps of decision making.

The condition assessment at this stage is more detailed and focuses on the feasibility and necessary work to be done with the chosen (or regarded) alternatives.

Costs for necessary work should be specified in detail.

Energy calculations should be done for the proposed or chosen alternatives and the results of the calculation should be compared with each other regarding costs and other important requirements.

Energy use should be benchmarked.

Tendering

The tendering process should ensure that the overall best offer is chosen. In order to achieve this aim it is important to have tendering document that allow the decision makers choosing the best offer regarding both quality and LCC.

3.3.3 Construction

In construction phase some parts and equipment are demolished and new elements are installed instead.

The close co-operation between the design group and the contractors is vital to achieve best possible result. As there may be some unidentified structures there is a need for detail design as demolishing and new construction proceed. And of course all the modifications made during the installations should be added to final drawnings.

During the construction close operation with design group, contractors and future users and operation and maintenance personnel enables the solid base for preparing building maintenance manuals and educations schemes. These preparations come handy in completion and handover phase.

3.3.4 Handover and operation

When the construction is finnished all the modifications made and new equipment added should be documented into building maintenance manual as well as all the life cycle cost assessments done.

It is responsibility of the whole design group, the contractors and the suppliers to provide all the documentation like guidebooks of new installations and materials for both users and maintenance personnel. Also adequate "how to use and maintain"- education should be organised for both groups. It is important include a clause in both the design and construction agreements about the responsibility for organising such event. It is so easy to forget these important phases at the end of refurbishment process. There is no good for fine new equipment if nobody knows how to use them properly.

Incorporating LCCA and especially Integrated Planning into refurbishment process is a demanding task. It requires new views and flexibility form all the parties involved into process. It may require also changes into education schemes for professionals.

Energy prices are climbing and building owners have to try to keep their property expenses level to attract tenants. By focusing some extra resources during the design and construction phase of refurbishment notable decrease during operation may be achieved. Through LCCA and IP it is possible to gain better income for the investments than by using the traditional building process.

4 Terms an definitions

4.1 Background

Following Terms and Definitions are trying to clear way for common terminology all over Europe. They are collected various sources and are not intented to be considered as final reference. The basis are from EN-CEN standarts and norms, ISO standarts, various national regulations and the work of The Finnish Association of Civil Engineers Lifetime Engineering Division.

4.2 Terms of Definitions

Acquisition cost (Initial capital cost)

All costs included in acquiring an asset by purchase or construction, excluding costs during the in-use phase of the life cycle.

Capital cost

Up front construction costs, (and the costs of replacements where they are treated as capital expenditure).

Condition

Level of critical properties of a building or its parts, determining its ability to perform.

Condition assessment, Zustandserklärung, Bedömning av skick

Methodology and methods for quantitave measurements and visual inspection of the properties of an object and ist parts ansd conclusions drawn from the results regarding to the condition of the object.

Current value of costs, Kapitalwert der Kosten, Kostnadernas nuvärde

The sum of costs over the design time period, discounted into current value.

Current value of the residual value, Kapitalwert des Residualwertes, Restvärdets nuvärde

The residual value discounted into current value.

Defect

Fault, or deviation from the intendedlevel of performance of a building or its parts.

Discount rate

The factor reflecting the time value of money that is used to convert cash flows occurring at different times to a common time. E.g. to convert future values to present values and vice versa.

Discounted cost

The resulting cost when real cost is
discounted by the real discount rate or when nominal cost is discounted by the nominal discount rate.

Durability, Dauerhaftigkeit, Beständighet

The capability of a facility or a part of it to maintain minimum performance under the influence of actual environmental degrading loads.

Economic Requirements, Ökonomische Anforderungen, Livscykelekonomiska krav

Requirements for the limits of incomes and the costs and of the profitability.

Ecological (Economy of the Nature) Requirements, Ökologische Anforderungen, Livscykelekologiska krav

Requirements of the life cycle economy of nature, having as variables the expenditures of the nature, in following cases:

- raw materials economy
- energy economy
- environmental burdens into soil, air and waters
- waste economy
- biodiversity and geodiversity

External costs

Costs associated with the asset which are not necessarily reflected in the transaction costs between provider and consumer.

Inflation/deflation

A sustained increase/decrease in the general price level Can be measured monthly, quarterly or annually against a known index.

Integrated planning, Integrierter Entwurf, Integrerad planering

The lifecycle synthesis and optimising design, taking into account all generic classes of requirements: Usability (social requirements), economy, ecology and culture.

Investor, Anleger, Investerare

Person or organisation which invests capital in order to gain proper internal rate of return for this capital.

Life cycle, Lebenszyklus, Livscykel

The period of time between a selected date and the cut-off year or last year, over which the criteria relating to a decision is assessed. This period may be determined by the client for the analysis (e.g. to match the period of ownership) or on the basis of the probable physical life cycle of the asset itself.

Life cycle cost (LCC), Lebenszyklus- Kosten, Livscykelkostnader

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.

Life Cycle Assessment (LCA), Lebenszyklus-Analyse

Calculation methodology for assessing the environmental aspects, environmental burdens and environmental consequences over all life cycles and over entire lifetime.

Life Cycle Performance, Lebenszyklus-Funktionsbarkeit, Livscykelfunktion

The capability of the facility to fulfil the performance over the specific life cycle period.

Maintenance, Instandhaltung, Underhåll

Combination of all technical and associated administrative actions during the service life to retain a building or its parts in a state in which it can perform its required functions.

Maintenance cost

The total of necessarily incurred labour, material and other related costs incurred in conducting corrective and preventative maintenance and repair on constructed assets, or their parts, to allow them to be used for their intended purposes.

Maintenance, Operating and Management costs (MOM)

The expenses incurred during the normal operation of a building or structure, or a system or component including labour, materials, utilities, and other related costs over the life cycle.

Net present value

The sum of the discounted future cash flows. It is often the standard criterion for deciding whether a programme can be justified on economic principles but other techniques are used and may be preferred.

Nominal discount rate

A rate used to relate present and future money values in comparable terms, taking into account the general inflation rate.

Optimation, Optimierung, Optimering
-short term optimation, kurzszeitoptimierung

Optimisation in short time period (usually one or a couple of years)

-long term optimisation, lanzeitoptimierung

Optimisation in long term period (usually several or even tens of years)

Performance Requirement, Funktions-Anforderung, Funktiuonskrav

Qualitative and quantitave level of performance reguired for a property of a facility.

Present value

Monies accruing in the future that have been discounted to account for the fact that they are worth less today.

Period of analysis

The length of time over which an investment is analysed, which may be shorter than the life cycle of the asset.

Predicted service life

Service life predicted from recorded performance over time.

Refurbishment or Rehabilitation, Instandsetzung, Reparation

Modification and improvements to an existing building or its parts to bring it up to an acceptable condition.

Repair

Return of a building or its parts to an acceptable condition by the renewal, replacement or mending of worn, damaged or degraded parts.

Residual service life

Service life remaining at a certain moment of consideration.

Residual value, Residualwert, Restvärde

The monetary value or ecological value of the facility or part of it at the end of design time period.

Real cost

The cost expressed in values of the base date, including estimated changes in price due to forecast changes in efficiency and technology, but excluding general price inflation or deflation.

Real discount rate

A rate used to relate present and future money values in comparable terms, not taking into account inflation (whether general or specific to a particular asset under consideration).

Residual service time, Residual-Lebensdauer, Restålder

The residual service life of a facility at the time of evaluation.

Service life, Lebensdauer, Bruksålder

Service life that a building or parts of a building would be expected to have (or is predicted to have) in a certain set (reference set) of in-use conditions. Period of time after installation during which a building or its parts meets or exceeds the performance requirements.

Service life planning, Lebensdauerplanung, Bruksålderplanering

Opitmising and defining the target service life of a facility and parts of it to control life cycle quality at the design and to facilitate maintenance and refurbishment on an optimised way.

Sensitivity analysis

A test of the outcome of an analysis by altering one or more parameters from initial value(s). These should be ignored in an appraisal. However the opportunity costs of continuing to tie up capital should be included in the analysis.

Service life planning

Preparation of the brief and design for the building and its parts to achieve the desired design life.
In order to reduce the costs
of building ownership and facilitate maintenance and refurbishment.

Stakeholders, Parteien, Parter

Owners, users, designers, contractors, operators, management organisations, industry sectors, public intrest organisations, regional interests and/ or government agencies connected to the facility during the life cycle.

Time value of money

Measurement of the difference between future monies and the present day value of money.

Uncertainty

Lack of certain, deterministic values for the variable inputs used in a LCC analysis of a structure, building, component etc. It is implicit that the projected costs are to achieve defined levels of performance, including reliability, safety and availability.

User, Anwender, Användare

Person or organisation which occupies a facility or acts in it.

Usability (or Social Requirements), Soziale (Anwendungs) Anforderungen, Användnings krav för livscykel

The life cycle requirements of an object, including usability, health, safety and convenience.

Whole life cost

An economic assessment considering all agreed projected significant and relevant cost flows over a period of analysis expressed in monetary value.

5 Best Practice Examples

One part of LCC-Refurb project was testing various life cycle cost assessment methods and putting them into practice. In many counties lcc and intergrated planning are not so widely used in construction, particularly in refurbishment.

In this chapter there are short descriptions about each partners pilot project, main actors and actions. There are also contact information if further information is needed.

BRG/BG Pestalozzistraße Graz

Address: Austria, Graz, Pestalozzistraße 5

Building Category: School building

General Information

Year of construction: 1911–1912

Gross floor space: classes wing: 4.290 m²
gym hall: 2.230 m²

Number of floors: 6

Heat demand: 89,94 kWh/m²a

Heating system: district heating

DHW system: district heating

Reasons And Goals Of Refurbishment

Reasons: poor condition of the school building in general and need of additional class rooms

Goals: refurbishment according to the current state of construction improving energy performance and specific quality aspects of the building

Steps Of Integrated Planning

Additional activities by LCC-REFURB project team in contrast to a standard
refurbishment process

DIAGNOSIS

Tools: technical visit and audits, interviews with building owner and tenant

Actions: data collection of the building together with the principal and the technical officer of the school; Building audit

Results: energy calculation, condition assessment, environmental assessment

BRIEF

Tools: guideline for refurbishment profile, LCC software

Actions: defining the obligatory measures and aims for the refurbishment activities in the fields architecture, functioning and space; indoor air climate and sound insulation as well as energy and natural resources; LCC calculations

Results: refurbishment profile, results of LCC-calculation

DESIGN

Tools: refurbishment profile

Actions: proposal for refurbishment activities

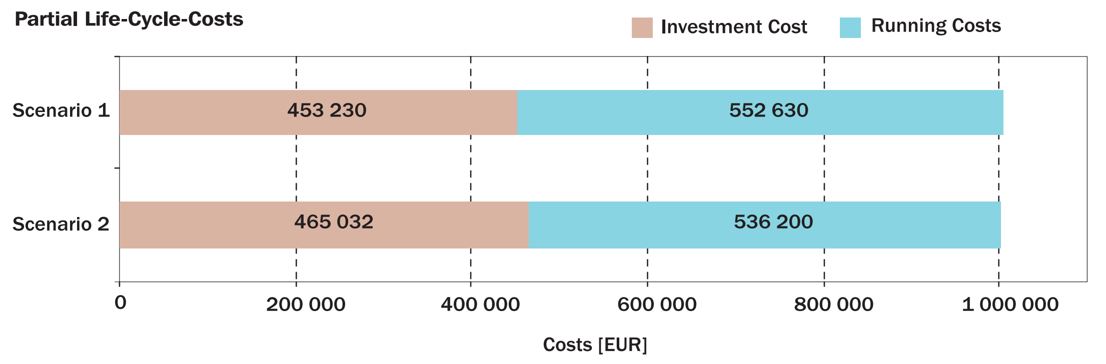
Results: inputs for bidding documents especially in the fields of energy efficiency, indoor air climate and ecological materials

CONSTRUCTION

Tools: monitoring concept in the construction phase

Actions: monitoring of refurbishment activities, especially in applying ecological-friendly materials and paints

Results: report on actual refurbishment works in the first phase of refurbishment



Result Of Life-cycle-cost Assessment

in comparison with a standard refurbishment process
The figure describes the total costs over the period of interest for standard refurbishment works (scenario 1) in comparison with an scenario taking into account LCC partially for specific measures (scenario 2).

The figure illustrates that scenario 2 which took LCC into account is the most cost-effective scenario over the period of calculation of 25 years.

- return of additional investment costs in 20 years
- additional reduction of energy costs by - 2.300 EUR per year

Benefits Of Integrated Planning

in comparison with a standard refurbishment process

- Improved insulation of exterior building parts (+ 12 cm)
- Better U-values of windows (- 0,2 W/m²K)
- Reduction of energy consumption (- 10.000 kWh per year)
- Applying ecological materials (low emission materials for better indoor air climate)
- Improved protection against sun gains (better summer comfort without A/C-system)
- More energy efficient heating system (- 10 % less heat losses)
- Better orientation guide in the building
- Modifications for handicapped accessible
- Additional reduction of CO_2 emissions (- 3,5 tons)

Modifcations of goals according to integrated planing

Additional to the current state of construction several parameters like energy efficiency, indoor air climate, ecological materials, shadings systems have been taken into account and were included in the bidding document.

Contact

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Building Tenant

Federal Ministry for Education, Science and Culture
Minoritenplatz 5
1014 Vienna, Austria
www.bmbwk.gv.at

Kustaankartano Centre for elderly

Address: Finland, Helsinki, Oltermannintie 32 block G

Building Category: Old people's home

General Information

Year of construction: 1954, renovated 1977, windows and roof renewed in 1990ies

Gross floor space: 3.500 m²

Number of floors: 4

Heating system: District heating

DHW system: District heating

Reasons And Goals Of Refurbishment

The aim of the refurbishment project is to improve the sanitary accommodations and the quality standard of the rooms. Some of the rooms are designed for three persons and after the refurbishment there will only be single rooms in the building. Furthermore, the HVAC and the electrical installations will be renewed. Also, the functionality of the rooms does not respond to the quality standards of today. The facade of the building and the windows will not be renewed, due to their good condition.

Steps Of Integrated Planning

The feasibility study started with the choosing of the designers for the study in March 2004. The main solutions of the building have been determined in May 2004. These solutions were based on present national building regulations, the operational and quality improvement aims set by the customers. These solutions were possible to change depending on the results of the LCC calculations.

PWD-Construction Management does not carry out the LCC calculations itself, the calculation services are outsourced. The LCC consultant, Optiplan Ltd, and the LCC tool were chosen in April 2004. Firstly, the basic solution was calculated. The alternatives to the basic design solution from the structural, the HVAC and the electrical designers for the LCC sensitivity analyses were completed in November 2004. The LCC sensitivity analyses of the alternative solutions were completed and reported in December 2004

The design phase started in May 2005 and the refurbishment will start in the beginning of 2006.

Result Of Life-cycle-cost Assessment

5 alternative solutions have been investigated, 3 for domestic hot water (solution 1: electric storage heaters, solution 2: gas-fired storage heaters, solution 3: solar system + gas-fired auxiliary system) and 2 for air-conditioning (solution 4: package air cooled chiller, solution 5: gas-fired absorption chiller + cooling tower).

A LCCA has been performed to assess the benefit of these 5 options. From this analysis it comes out that solution 3 for domestic hot water and solution 4 for air-conditioning were the cheapest ones over the calculation period (30 years).

Benefits Of Integrated Planning

For this site, focus is laid on assessing the cost-effectiveness of the additional investments proposed by the structural, the HVAC and the electrical designers. The basic design solution was the reference LCC value. The life cycle costs consist of site investments, maintenance measures carried out during the period under examination and use of the

PROPOSAL	INVESTMENT €	SAVINGS €/a	PAYBACK PERIOD in years with the value of savings increasing by x % p.a.				
			0 %	5 %	10 %	15 %	20 %
Underfloor heating	58 500 €	1 954 €	-	-	20	16	13
Pumps	2 272 €	41 €	-	-	-	-	17
Tap	420 €	17 €	-	-	-	14	12
Pressure	390 €	126 €	4	4	4	4	4
Heat recovery	5 160 €	266 €	-	-	15	12	11
Pipe system	1 860 €	42 €	-	47	26	19	16
Corridor lighting	5 250 €	1 404 €	5	4	4	4	4

Summary of LCC analyses

building. For shorter periods under examination, the residual value was taken into account. In long-term use the costs arising from use and maintenance of building are considerably higher than the investment cost of the site. Life cycle cost calculation aims at the most economical solution from the standpoint of overall economy. Sometimes this involves higher investment costs which, however, during the depreciation period of the solution will pay themselves back.

Savings will be achieved with additional investments. The estimate is made by calculating the payback period of the additional investment arising from the savings.
When calculating the payback period, the nominal interest rate used was +5 % and two energy price development alternatives were used case specifically. The starting price for electricity was € 80/MWh and for district heating € 33.03/MWh.

Nine different cases were calculated. The cost-effectiveness of the alternatives can be grouped into three classes of recommendation: Class A highly recommendable investment (= short payback period), Class B questionable investment (= long payback period calling for major energy price rise) and Class C financially unprofitable investments (call for an annual energy price rise of more than 10 %).

Class A (highly recommendable investments) include:

- pressure reduction valve for household water
- automatic control adjustment devices and presence detectors for corridor lighting
- motion detector for the balcony radiation heater

Class B (investments with questionable cost-effectiveness) include:

- under floor heating with district heat (20 years, 10 %)
- conversion of heat recovery (15 years, 10 %)
- pressure reduction of heating pipe system (26 years, 10 %)

Class C (unprofitable investments) include:

- conversion of heating pumps to frequency converter power
- electronic taps

Contact

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Hotel MERCURE St Georges

Address: Rue Saint Jérôme - Place Occitane
31000 Toulouse

Building Category: Hotel

General Information

Year of construction: 1974

Gross floor space: 7 900 m²

Number of floors: 7 + 2 under floors

Heating system: Gas-fired boilers

DHW system: Electric hot water storages

Annual billed hot water consumption: 2 964 m³/yr (2003)

Annual billed energy consumption: 768 MWh/yr (2003)

Annual billed electricity consumption: 1 586 MWh/yr (2003)

Reasons And Goals Of Refurbishment

Reasons: An audit has been performed on the building hotel. This audit has shown:
- The electricity consumption is higher than average electricity consumption of similar hotels (***).
- The DHW consumption is higher than average DHW consumption of similar hotels.
- Some equipments are in poor state or are not able anymore to meet the demand and must be replaced.
- Some hotel rooms are not air-conditionned and complaints from hotel guest have been monitored.

Based on this audit, the hotel manager decided to study a refurbishment scheme concerning mainly technical systems.

Goals: The main goals of this refurbishment are:
- Adapt technical systems (heating, cooling, ventilation and domestic hot water production) to meet guest expectations.
- Reduce operating costs.
- Increase thermal comfort in hotel rooms.

Steps Of Integrated Planning

Additional activities in contrast to a standard refurbishment process

DIAGNOSIS

Tools: XENIOS (audit tool for hotel building), interviews

Actions: technical visit and audits, data collection of the building together with the building manager and the hotel caretaker

Results: consumption history, condition assessment

BRIEF

Tools: energy calculation tools, literature survey, LCC software

Actions: definition of alternative energy conservation solutions to be analysed, data collection, LCC calculations

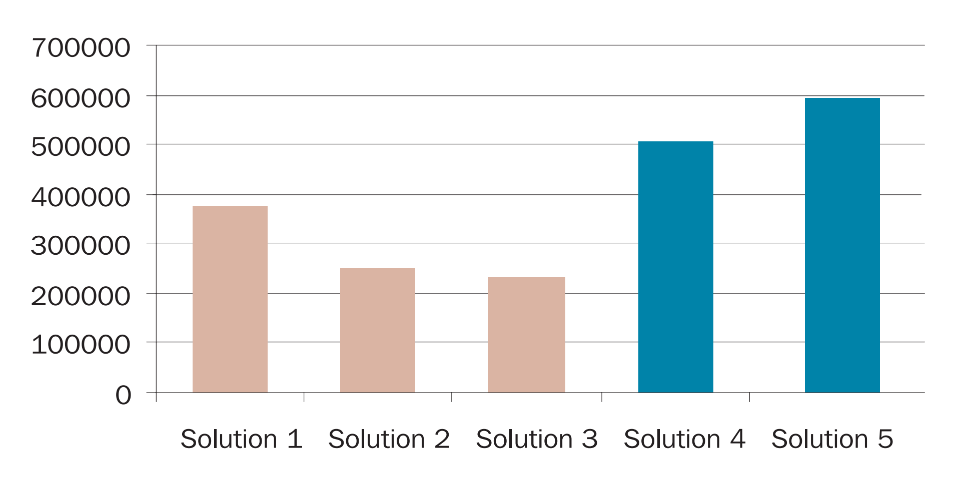
Results: energy calculation, results of LCC-calculation

DESIGN

Tools: refurbishment profile

Actions: proposal for refurbishment activities

Results: inputs for bidding documents especially in the fields of energy efficiency and indoor air climate



OPERATION

Tools: –
Actions: –
Results: definition of replacement frequencies

Result Of Life-cycle-cost Assessment

5 alternative solutions have been investigated, 3 for domestic hot water (solution 1: electric storage heaters, solution 2: gas-fired storage heaters, solution 3: solar system + gas-fired auxiliary system) and 2 for air-conditioning (solution 4: package air cooled chiller, solution 5: gas-fired absorption chiller + cooling tower).

A LCCA has been performed to assess the benefit of these 5 options. From this analysis it comes out that solution 3 for domestic hot water and solution 4 for air-conditioning were the cheapest ones over the calculation period (30 years).

Benefits Of Integrated Planning

in comparison with a standard refurbishment process

- 10% energy saving. This rather low figure is explained by the fact that a private sector company is not interested in reducing energy consumption but operating cost. Given the tariff structure of energy it is more relevant to select solutions having higher energy consumptions but lower running cost.
- The impact of operational and maintenance costs over the life of the building has been estimated (represent from 70 to 80% of the life-cycle cost).

Modifcations of goals according to integrated planing

The building management department of ACCOR group, who was in charge of this project, almost validated this analysis except for domestic hot water where solution 2 was preferred instead of solution 3 even if it was more expensive (+9%) and less energy-efficient (+40%). The reason why solution 3 was not kept was a previous bad experience with thermal solar. Their primary interest in almost every case is to achieve trouble-free usage of premises.

A full design of every part and component of the building was produced and a call for tender was launched in march 2005. The construction phase is scheduled from July 2005 to September 2006.

Contact

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Building Owner
ACCOR hotel resort
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Building Manager
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AOK – Die Gesundheitskasse

Address: Germany, Berlin

Building Category: Medical and office building

General Information

Year of construction: 1960

Gross floor space: 9.000 m²

Heat demand: 120 kWh/m²

Reasons And Goals Of Refurbishment

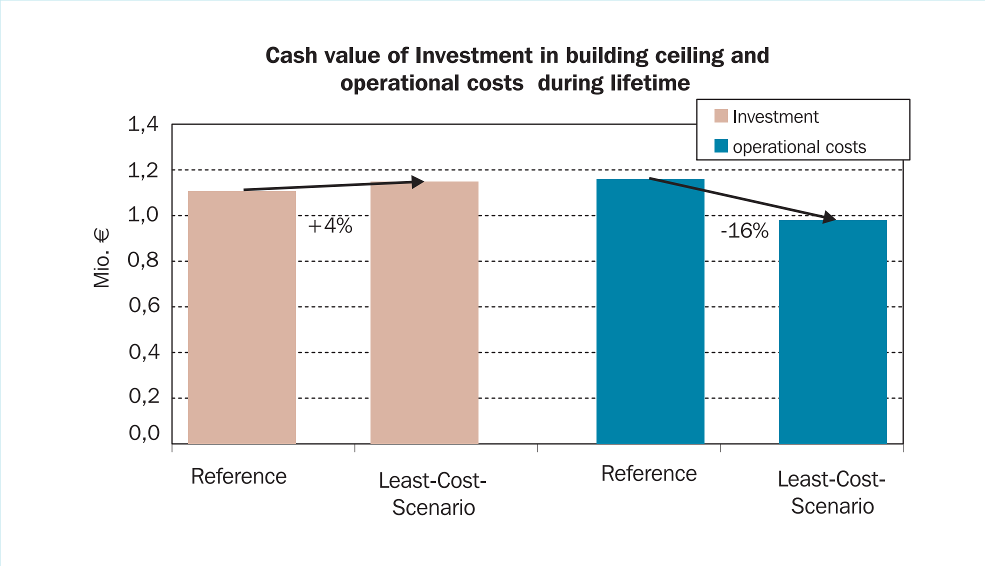
The demonstration building is a combined medical and office building, which contains offices, surgeries and a service center. It is owned and completely used by the AOK, which is the biggest public health insurance in Germany. Because of its main functions the building has lots of visitors.

Together with the building owner the overall goal for the refurbishment was set to find the solution with the lowest total costs during the rest of the lifespan of the building, which was set to 35 years (until 2040).

Steps Of Integrated Planning

The main part of the consulting happened during diagnosis and the brief phase. By gathering the consumptions (heating and electricity) the basis for benchmarks and the definition of goals was set.

When BE entered the planning process the architect had already developed a proposal for the refurbishment of the building which was used as reference scenario for the following LCC-calculations. During the brief phase LCC-calculations for 5 scenarios (actual state, reference scenario by architect, 2 scenarios with increasing energy efficiency, 1 best scenario which contains the best from reference and



the 2 further scenarios) were analysed. To have a clear view of the results the calculations where only done for the respective components (roof, walls, floor and heating system).

Result Of Life-cycle-cost Assessment

The scenario which causes the lowest total costs during lifetime of the building reaches the following performance indicators (compared to the reference scenario):

- Reduction of energy demand 30%
- Reduction of operational costs 16%
- Reduction of life-cycle-costs 6%
- Increasing of investment costs 4 %
- Reduction of CO2-emissions 40 t/a

The Results of the LCCA are also stable with different increase rates of energy costs.

Benefits Of Integrated Planning

in comparison with a standard refurbishment process

- 10% energy saving. This rather low figure is explained by the fact that a private sector company is not interested in reducing energy consumption but operating cost. Given the tariff structure of energy it is more relevant to select solutions having higher energy consumptions but lower running cost.
- The impact of operational and maintenance costs over the life of the building has been estimated (represent from 70 to 80% of the life-cycle cost).

What are the effects?

The building owner wants to follow the recommendations from the LCCA-calculations for the ongoing process.

Contact

Project Management

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Building Owner

AOK – Die Gesundheitskasse
Wilhelmstraße 1
10957 Berlin

Volos City Museum

Address: Greece, Volos, Ferron 17 str.

Building Category: Ex tobacco warehouse
(to be totally refurbished)

General Information

Year of construction: 1910–1920

Gross floor space: 1.830 m²

Number of floors: 3

Heat demand: 65 kWh/m²a

HVAC system: Central (N.Gas & electric)

Reasons And Goals Of Refurbishment

Reasons: Abandoned building with historical value, needing attention in order to prevent further deterioration. Chosen as an ideal building to house the new city museum.

Goals: Total refurbishment and structural improvement according to present construction and museum study norms, coming up with a quality building.

Steps Of Integrated Planning

Additional activities in contrast to a standard refurbishment process

DIAGNOSIS

Tools: technical visit and audits, interview
Actions: data collection of the building together with the technical officers of the Volos municipality.
Results: energy calculation, condition assessment, analysis of existing full refurbishment study.

BRIEF

Tools: LCC software
Actions: defining the obligatory measures and aims for the refurbishment activities in the fields architecture, functioning and space; indoor air climate and sound insulation as well as energy and natural resources; LCC calculations
Results: refurbishment profile, results of LCC-calculation

DESIGN

Tools: refurbishment profile
Actions: proposal for refurbishment activities
Results: inputs for bidding documents especially in the fields of energy efficiency

CONSTRUCTION

Tools: –
Actions: will follow
Results: –

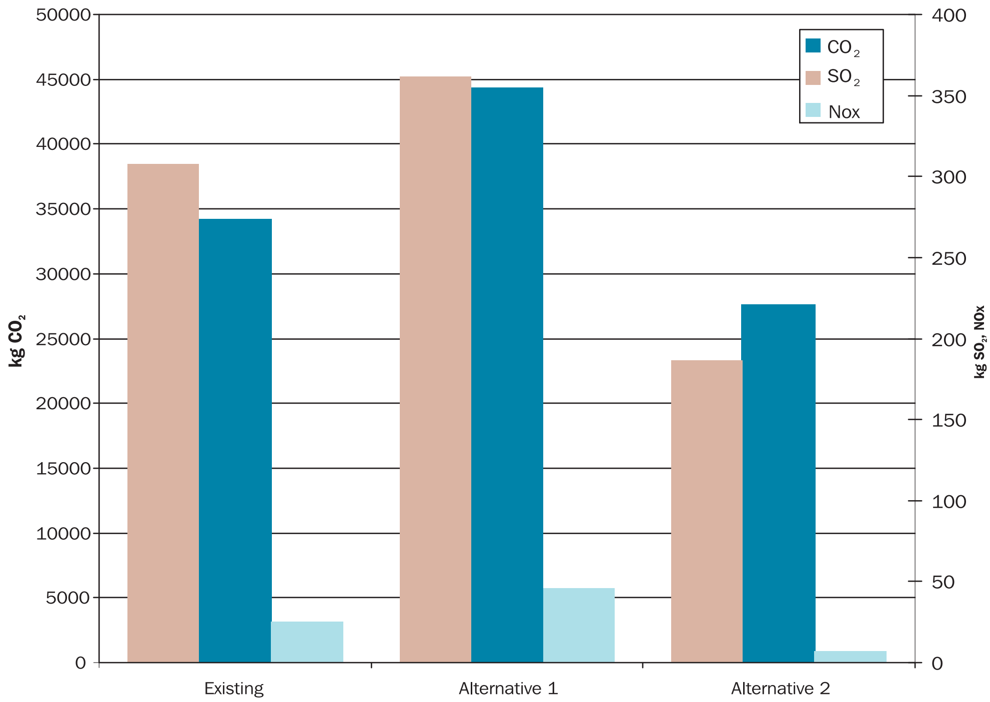
OPERATION

Tools: –
Actions: –
Results: –

Result Of Life-cycle-cost Assessment

in comparison with a standard refurbishment process

The scenarios being examined for the HVAC system are 3 namely, 1. Heating with N.Gas & electric cooling, 2. Heating with petrol & electric cooling and 3. Heating with N.Gas & absorption cooling. For scenario 3 there is a net saving of €18727 over the 25 year life of the system plus a considerate CO_2 emissions reduction of 6 tones, 130 kg SO_2 and 30 kg NOx. The figure below shows the existing (no1 scenario), no 2 and proposed no3. (comparison is between no1 and no3).



Benefits Of Integrated Planning

in comparison with a standard refurbishment process

- Better understanding of the effect of present decisions on life cycle costs
- Reduction of energy consumption (- 7.850 kWh per year)
- More energy efficient heating system (- 10 % less heat losses)
- Additional reduction of CO_2 emissions (- 6 tons)

Modifcations of goals according to integrated planing

Additional to the current plan of refurbishment several parameters like energy efficiency, indoor air climate and shadings systems (natural cooling) have been taken into account and were presented to the municipality. For natural cooling the LCC savings is only €4000 over a 25 year period and the CO_2 emissions reduction is 1.5 tones.

Contact

Project partner

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Akershus Fortress

Address: Norway, Oslo, Akershus, buildings 49, 52, 53, 61 and 63

Building Category: Head Quarter and Administration Building

General Information

Year of construction: 1850–1860

Gross floor space:

Buildings to be refurbished	
Building 49 (school)	3 259 m^2
Building 52 (work shop)	4 477 m^2
Building 53 (office)	657 m^2
Buildings to be demolished	-860 m^2
Total exiting buildings	7 528 m^2
New buildings	
Building 6	10 059 m^2
Building 63	314 m^2
Total new buildings	10 373 m^2
Total project	17 901 m^2

Number of floors: 2-4

Reasons And Goals Of Refurbishment

The Norwegian defence is building a new head quarter and administration building in connection with the Akershus fortress in Oslo. The project includes both demolishment and refurbishment of existing buildings, as well as adding a new building.

The buildings will be used 24 hours/day and every day, which influence the performance requirements concerning lightning and ventilation as well as heating. The buildings will be connected to the district heating system, and heated by use of low temperature water system.

The existing buildings in questions were to put to their original state f.ex:

- Removal of non-original walls and ceilings in the school building and the work shop building
- The exterior of the office building will be kept, and the building will form the entrance to the new administration building.

Building 52, work shop building, is a 2–4 storied building with 2 towers. The building is a traditional brick construction. The windows were a mixture of original and newer windows, many different sizes, wood or metal frames, mainly single glass. The height of the rooms differed, with an average of 4.0 m.

Building 49, the school building, is a 2–3 storied building, mainly plastered brick walls. The windows were mostly original wooden double glass windows. The conditions of the windows were quite good. The height of each storey was approx 4.2 m.

- The buildings had not been in regular use the last years, and energy use was not known.
- The total project aiming to be a energy efficient office building with high indoor air quality and comfort as well as low impact to the environment.

Steps Of Integrated Planning

Analyses of upgrading alternatives for windows, concluding recommendation of keeping and repair original windows, adding extra glass and internal frames for larger windows in work shop building.

- Energy demand calculations
- LCC analysis
- Environmental assessment

LCA and use of Eco-indicators

Result Of Life-cycle-cost Assessment

Theoretical energy use before and after refurbishment were calculated, and showed for building 49 a reduction in energy use from 351 kWh/ m2year to 324 kWh/ m^2year building 52 a reduction in energy use from 341 kWh/ m^2year to 286 kWh/ m2year. Normally older office buildings like these will have an energy demand of 193–213 kWh/ m^2year.

- The demolition and new construction have started, and the project will be finalized in 2006.

Contact

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Building owner:

Norwegian Defence Estates Agency

Retail trade shop Mercator

Address: Slovenia, Ljubljana, Na Gmajni 1

Building Category: Tertiary building – commercial

General Information

Year of construction: 1964

Gross floor space: 610 m² (net floor area)
shop and storage

Number of floors: ground floor + partly cellar

Envelope insulation level: poor, light weight concrete

Net heat demand
(calculated per net floor area): 102 kWh/m² a

Final energy for space heating
(gas in 2003): 125 kwh/m² a

Heating system: gas fired boiler 93 KW

Cooling: split ACs, occasionally used, operated manually

Electricity use
(refrigerators, lighting, cooling): 335 kWh/m²a

DHW: local electric heaters

Reasons And Goals Of Refurbishment

Reasons: Low thermal comfort in the building, overheating/overcooling problems, the building needs renovation due to functional and aesthetic reasons to be attractive for buyers

Goals: Refurbishments according to the current standard of shop workspace, improve energy efficiency & reduce heating costs by cost - effective measures, that also contribute to indoor comfort

Steps Of Integrated Planning

Additional activities in contrast to a standard refurbishment process

DIAGNOSIS

Tools: interviews, technical visit and audits, energy use and costs, T measurements, thermography

Actions: data collection of the building together with the investment dept., architect, user – head clerk and Mercator accounting dept

Results: energy calculation, condition assessment, environmental assessment

BRIEF

Tools: refurbishment scenarios, IDA – energy simulations, LC profit software

Actions: energy, costs and CO_2 indicators for indicators of existing condition, definition of provisional measures and refurbishment scenarios, defining the targeted performance of refurbished building (thermal, visual comfort, environmental impact); LCC calculations

Results: refurbishment profile, results of LCC-calculation

DESIGN

Tools: refurbishment profile

Actions: matching of proposal for refurbishment activities with regular design process

Results: plans ready; recommendation for shop building refurbishment (in the fields of energy efficiency, envelope, natural ventilation strategy, environ mentally friendly materials)

CONSTRUCTION

Tools: monitoring concept

Actions: monitoring of refurbishment activities

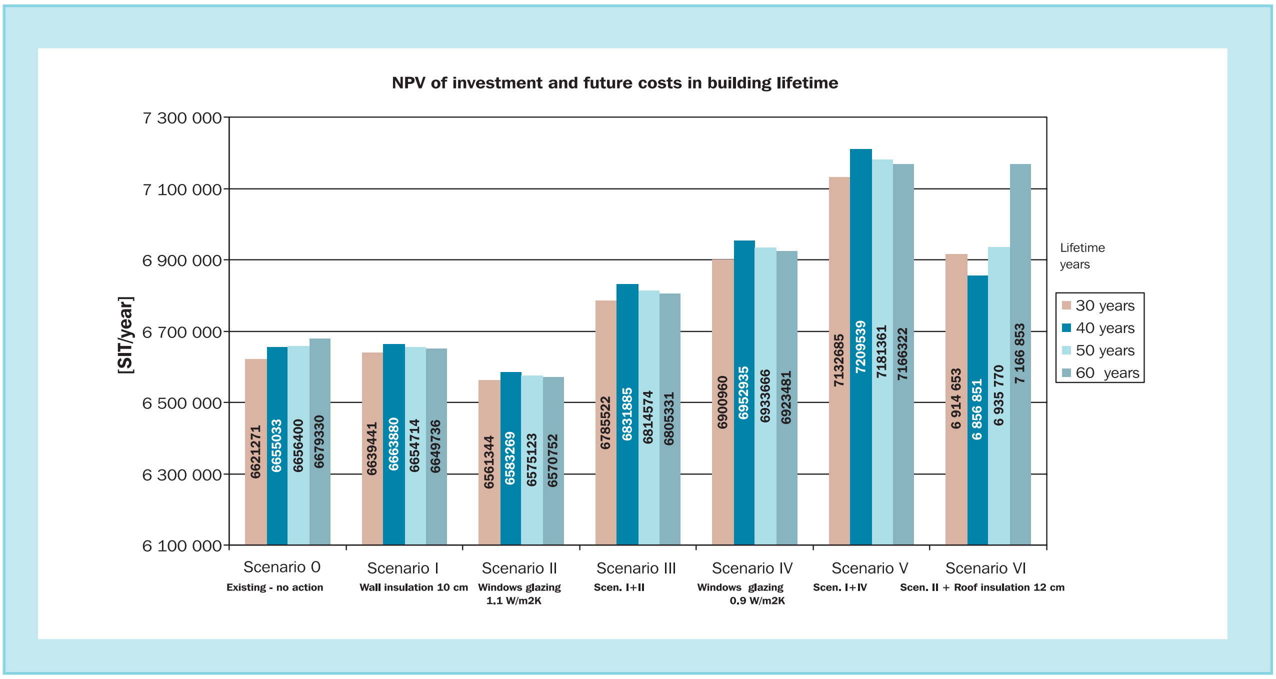
Results: report on actual refurbishment works

OPERATION

Tools: monitoring of refurbished building performance

Actions: data on energy use and energy costs, thermography

Results: comparison of before – after performance indicators



Result Of Life-cycle-cost Assessment

in comparison with a standard refurbishment process

The figure presents the scenarios 0-VI compared during LCC. The scenario II (new en.eff. windows) demonstrated the lowest NPV value. Scenarios including outer insulation on opaque parts were not economically feasible. Although economic evaluation of envelope measures often reveals the problem of high investment costs, in this case the exchange of windows was part of cost effective scenario (single glazed old shopping window).

Scenario II demonstrated – for 30 years period of calculation (building service life):

- Energy savings of 18.900 kWh/year
- Reduced energy costs for aprox. 800 EUR/year
- Significantly lower NPV than in reference scenario

In further steps of the design process, also the roof insulation was incorporated in the secondary ceiling, which was implemented for aesthetic and technical (ducts) reasons. Scenario II was completed with instructions for summer shading and natural ventilation
during night time (for better thermal comfort without cooling devices).

Benefits Of Integrated Planning

in comparison with a standard refurbishment process
New energy efficient windows (and glazing) were installed, additional roof insulation layer (complementary to scenario II, i.e. scenario VI),

- passive cooling – occasional use of nighttime natural ventilation instead of AC,
- additional shading on south glazed areas installed,
- improved thermal comfort,
- Indicated energy savings 33 kWh/m2year (scenario VI),
- 25% less energy for heating,
- up to 1000 EUR/year savings for heating due to scenario proposed on LCC
- reduction of emissions for 3,8 tons CO_2,
- importance of professionalism in running of building control system,
- consultants and the building owner became aware of the impact of various parameters assumed in LCC calculation (sensitivity analysis needed),
- building owner committed itself to integrate LCC & IP into further refurbishment process.

Contact

Project management

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Building owner

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Planning documentation

Mercator Optima

Old people's home Rozmital pod Tremsinem

Address:	Czech, Rozmital pod Tremsinem Na Spravedlnosti 589
Building Category:	Tertiary sector
General Information	
Year of Construction:	1972 (pavilion A, B, C) 1986 (pavilion D)
Reconstructions:	1995 – wall and roof heat insulation in accordance with CSN 74 0540:1995
Heated floor space:	6 137 m²
Built-up heated space:	19 224 m³
Number of floors:	3 (pavilions A, B, C), 4 (pavilion D)
Energy performance:	131% (pavilion A, C), 139% (pavilion B), 113% (pavilion D)
Heating system:	liquid fuel oil boiler room from 1996 (843 kW), Equithermal regulation
Domestic hot water:	preheating with solar panels, heating with heating water or electricity
Yearly energy consumption for heating and HUW warming:	1 982 MWh/year

Reasons And Goals Of Refurbishment

Reasons: The prices of energy are constantly rising, high operational cost
Substandard condition
Need for capacity increasing

Goals: Reduction of energy consumption
Increasing of indoor thermal comfort

Steps Of Integrated Planning

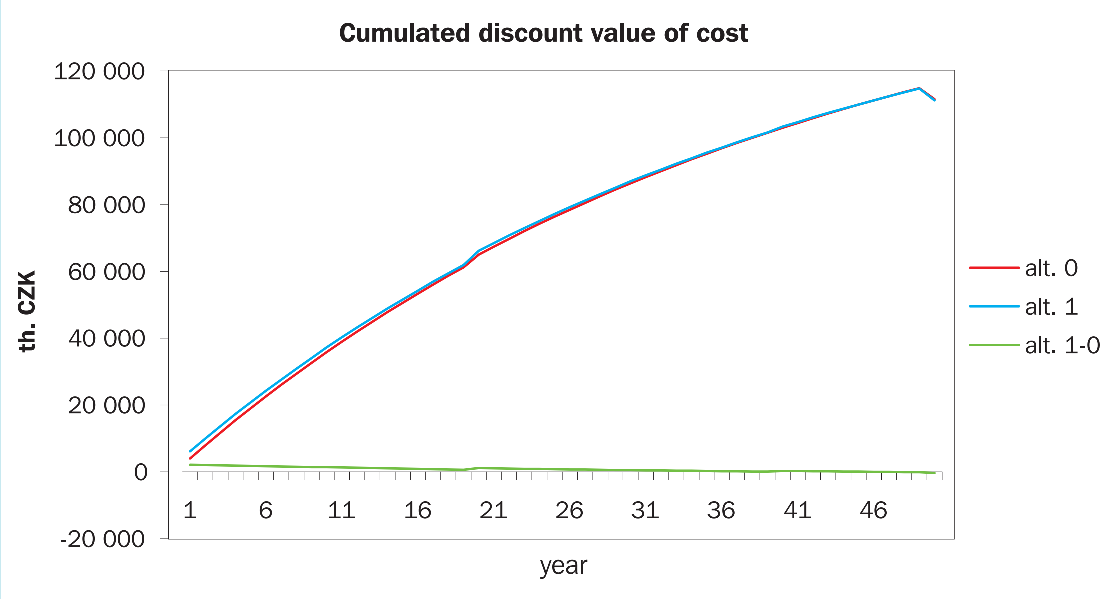
Additional activities in contrast to a standard refurbishment process

DIAGNOSIS

Tools: technical visit and audits, interview

Actions: energy audit, data collection

Results: condition, energy and environmental assessment



BRIEF

Tools: energy performance and LCC software tools
Actions: refurbishment scenarios, calculations
Results: energy calculation and LCC-calculation

DESIGN

Tools: refurbishment profile
Actions: proposal for refurbishment activities
Results: inputs for further design

CONSTRUCTION

Tools: –
Actions: Initiation of construction work depends on decision making process procedure at Central Bohemian Authority
Results: –

OPERATION

Tools: monitoring of refurbished building performance
Actions: data on energy use and energy costs
Results (presumed): comparison of before – after performance indicators

Result Of Life-cycle-cost Assessment

in comparison with a standard refurbishment process

3 alternative refurbishment solutions have been compared with "nothing done" alternative. The calculation period was set to 50 years. On the basis of LCCA there was chosen the alt. 2 which means implementation of detailed energy management, change of electricity tariff, windows replacement and change of fuel heating basis to natural gas. Scenario shows benefits of chosen alt. in contrast with "nothing done" alternative.

Benefits Of Integrated Planning

in comparison with a standard refurbishment process

- energy savings of 347 MWh/year
- reduction of operation cost
- reduction of CO^2 emissions
- improved thermal comfort
- widening of awareness about benefits of LCC between the building owners and consultants

Modifcations of goals according to integrated planing

Additional to the current state of construction more parameters like energy efficiency, indoor air climate, ecological materials should be taken into account in decision making process.

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6 Annex

6.1 Tools and input data

6.1.1 Tools for Life-Cycle-Cost-calculations

No standardised software is available. Methods differ from software to software and country to country. Basically all software deal with costs, time and interest rate. Additional software is often needed for energy calculations etc.

6.1.2 Input Data and Key Number

Life-cycle-cost calculations at an early stage are depending on available input data. Costs based on experiences, statistical information as key number, may be used as input. A well defined classification system for the categorisation of expenses and other input data is important for a successful use of LCCA.

Key numbers may be found from statistical treatment of collected data. For instances energy use/energy costs pr m^2, cleaning costs pr m^2, or cost used for management or maintenance for different building categories (function and age).

Key numbers may be used for benchmarking, as all users may compare their actual data with the collected data, and hence know how their use and management of the building is compare to others.

For a well defined cost classification system some basic factors are essential:

- Every item has to be well defined at each cost level so that it is clear and significant in order to facilitate the decision making process.
- Different users can subdivide the different costs on a two or three number level.

6.1.3 Relevant Sources for Input Data

Costs

Investment cost for different actions, i.e new installations, repairs or refurbishment could be found from different sources:

- Experience data from other projects
- Information from supplier or other actors

For LCC-calculations information of service life, life time or maintenance periods is an important input. For building products the supplier should give the necessary information. This information should be compared to experience.

Maintenance costs may be given by suppliers, or collected from experience. Collected key numbers might be of significant use.

6.1.4 Classification of Costs

A further splitting up into sub categories can be carried out as described in the Annex 6.3.

Table 6 1 Definition of main items

No	Main item	Definition
1	Capital	All investments for the completion of the refurbishment including decommissioning of the facilities
2	Administration	Activities for administration, required payment and insurance costs
3	Operation	Includes daily, weekly and monthly activities that are repetitive within a one-year period for the building and for technical installations that shall satisfy given functional demands and requirements
4	Maintenance	Includes all activities and efforts necessary in a period of more than one year. For example, planned maintenance, replacement and emergency repairs, so that the building and technical systems satisfy functional demands and requirements
5	Developing	Includes activities as a result of changes in demands of core activity, the authorities, total refurbishment, or all activities to raise the construction standards in relation to the original standard.
6	Consumption	Includes resources such as energy and water, but also waste handling.
7	Cleaning	All activities inside and outside of the building for satisfying cleaning demands
8	Service	All non-building related activities in support of the core activity

6.2. Overview of LCC Tools

Characteristics and applicability	Tool	BSLCC	Cost Benefit Hand-book	Easy SanFin	Eko-arvio	EPIQR	GEMIS CZ	IDA	LC Profit	LEGEP	LISA-LCA	Méthode convent 2)	RELEX LCC	Total Quality
Building age	New building	2	2	2	2	0	2	2	2	2	2	2	1	2
	Refurbishment	2	2	2	2	2	2	2	2	2	0	0	1	2
Type of building	Residential building	2	1	2	2	2	1	2	0	2	2	2	1	2
	Office building	2	1	2	2	1	1	2	2	2	2	1	1	2
	Educational building	2	1	0	2	0	1	1	2	2	2	1	1	1
	Hotel and restaurant	2	1	0	1	1	1	1	0	2	2	1	1	1
	Sport facilities	2	1	0	1	0	1	1	0	0	1	0	1	
	Wholesale buildings	2	1	0	2	0	1	1	0	2	1	0	1	1
	Other types of buildings	2	0	0	0	0	0	1	0	0	0	0	1	1
Input data	**Costs**													
	Costs in the decision making ph.	2	2	2	0	2	0	0	0	0	0	2	2	
	Costs in the design phase	2	2	2	0	0	0	0	0	2	0	0	2	
	Costs in the construction phase	0	2	0	0	0	0	0	2	2	0	0	2	2
	Costs in the utilisation phase	2	2	2	2	2	0	0	2	2	0	2	2	2
	Costs in the demolition phase	0	2	0	0	0	0	0	0	2	0	0	2	2
	Energy parameters													
	Energy consumption	0	2	2	2	2	2	2	2	2	2	2	0	
	Energy demand	0	0	2	2	2	2	2	2	2	0	2	0	2
	Further qual. parameters	0	2	0	0	2	2	2	0	2	2	0	0	2
Output data	**Indicators**													
	Life cycle costs	2	2	2	2	0	2	0	2	2	0	2	2	
	Economical benchmark	0	0	0	0	2	2	0	0	2	0	0	2	
	Energy related indicators	0	0	2	2	2	2	2	2	2	2	0	0	
	Qualitative indicators	0	0	2	2	2	0	0	0	2	0	0	0	2
	Evaluation	2	2	2	2	2	2	2	0	2	2	2	2	2
Language	English	0	0	0	0	2	2	2	2	2	2	0	2	
	Other 1)	fi	cz	de	fi,no	de,fr,gr,it,no,dk	cz	0	no	de,fr	0	fr	0	de
Tool is suitable for	Experts	2	2	2	2	2	2	2	2	2	2	2	2	1
	Rookies	0	0	0	0	0	0	0	0	0	2	0	0	2
Interface	Microsoft Excel	0	2	0	2	0	2	0	2	2	2	0		2
	Internet tool	0	0	0	0	0	0	0	0	0	0	0		
	Special programme	2	0	2	0	2	0	2	0	0	0	0	2	
Year of latest version		2004	2003	2003	2002	2003	2004	2001	1998	2004	2004	2002	na	2002
Number of tool users (companies)3)	Operators (consultants)	1-2	>30	na	3-10	10-30	3-10	na	na	>30	>30	3-10	na	3-10
	Clients	1-2	na	na	>30	>30	>30	na	na	>30	na	10-30	na	10-30
Number of realised projects 3)		1-5	na	na	>100	>100	>100	na	na	>100	>6-20	na	na	6-20

Legend	
2	true (or 3 high number)
1	partly true (or 3 medium number)
0	not true (or 3 low number)
na	data is not available

1) Abbreviations

cz	de	dk	fi	fr	gr	it	no
Czech	German	Danish	Finnish	French	Grecian	Italian	Norwegian

2) Méthode conventionelle de calcul du couût global énergétique des bâtiments

6.3 Detailed Categories of Costs

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

Table 6 2 Classification of costs

1	Capital costs	
11	Project costs	Includes all investments up to the finished construction. It can be subdivided in contractors costs (similar to enterprise costs), employee costs (fee, etc) and special costs (taxes, etc). It will be outlined that the contractor's costs can be divided into groups with the same rate of depreciation. Land costs shall be included. If it is a yearly fee then it should be calculated to net present value.
19	Remaining costs	Costs for elimination of construction at the end of its useful lifetime. This can also be the period of use. In some circumstances the remaining costs can be income. For example, the sale of the used construction materials for new projects or the whole building for new use.
2	Administration costs	
21	Taxes and fees	Property tax and other required official fees (and independent expenditures) even if the structure is not in use
22	External fees	Include external assistance fees to the management, eg. condition survey, legal assistance etc.
23	Administration and management	Salary to administrative employees. Also includes rent of space for the use of management department, documentation of the construction inclusive the management of data based system for MOMD, the service desk, marketing, internal control, etc.
24	Insurance	Includes fire and burglary. Also insurance for necessary building equipment to the management department. Casualty insurance and personal property of user is not included under this insurance.
29	Various	Example equipment for operation department
3	Operation costs	
31	Operation and inspection executed by own employees	Salary and all payments to employees (excluded are administration) including work clothing, materials and equipment, tools, etc. Work assignments worth mentioning: lubrication, adjustments and regulations of technical systems, fire protection, etc including filters, bulbs, straps etc.
32	Operation and inspection executed by external companies	Includes all external agreements (service agreements) for operation and supervision of elevators, fire alarms, sprinkler systems, ventilation systems, etc.
37	Outdoor operation and inspection executed by own employees	Salary and all payments to employees (excluded are administration) including work clothing, materials and equipment, tools, etc. for snow removal, landscape services, operation of technical construction and systems, etc. (does not include parking buildings).
38	Outdoor operation and inspection executed by external companies	Includes all external agreements (service agreements) like snow removal, landscape services, operation of technical construction and systems, etc. (does not include parking buildings).
39	Various	

4	Maintenance Costs	
41	Periodical maintenance of exterior of the building	Includes work on the façade and roof that is necessary to prevent decay of normal wear and tear.
42	Periodical maintenance of internal of the building	Includes work on the interior of the building to prevent decay with normal wear and tear.
43	Replacement of exterior	Includes replacement of exterior building components (roofs and facades), for example, work and efforts that are necessary in order to accomplish replacement as a consequence that periodic maintenance no longer satisfy maintaining technical and functional demands (parts of the building that have shorter lifetime than the rest of the building).
44	Replacement of interior	Includes replacement of interior of the building, for example, work and efforts that are necessary in order to accomplish replacement as a consequence that periodic maintenance no longer satisfy maintaining technical and functional demands (parts of the building that have shorter lifetime than the rest of the building).
45	Emergency repair work for exterior	Includes work and efforts that are necessary to correct unforeseen situations. Includes emergency efforts to the façade and roof and aligning of damages.
46	Emergency interior repair	Includes work and efforts that are necessary to correct unforeseen situations. Includes emergency efforts to the interior and aligning of damages.
49	Outdoor	Periodic maintenance and replacement of building components including technical systems i.e. fountains, asphalt, trees and bushes, fences and retaining walls.
5	Developing costs	
51	Development and upgrading of exterior of the building	Includes costs of ongoing efforts caused by new demands from authority or core business related. For example, new fire or environment regulations.
52	Development and upgrading of internal of the building	Includes costs for ongoing efforts caused by new demands from authority or core business related. For example, new fire or environment regulations that give retrospective force and thereby includes all buildings and simple rebuilding.
59	Development and upgrading outdoor	Includes costs as followed by demands from activity, the authority or in connection with total renovating that will elevate the quality.
6	Consumption costs	
61	Energy	All costs related to energy supplies including oil, electric and heating
62	Water and drainage	All costs related to water consumption as intake water, waste water including cleaning.
63	Waste handling	Includes all costs from internal transport, compression, source separation, collecting (hired container), transporting related to waste and taxes for landfill.
69	Various	
7	Cleaning costs	
71	Daily/Periodic	Includes daily and weekly cleaning of all surfaces, including accessories and equipment
72	Main cleaning	Includes costs to periodic main cleaning, includes accessories and equipment
73	Special cleaning	Includes, for example, floor waxing, etc. and includes accessories and equipment.
74	Window cleaning	Periodic interior and exterior window cleaning when this usually gets charged to the owner of the building or respective user.
75	Façade cleaning	Costs for façade cleaning inclusive all necessary help. Usually performed in connection with exterior window cleaning.
79	Outdoor cleaning	Includes cleaning of cultivated areas. Maintenance of the green areas is not included.

8	Service costs	
81	Security and safety	Security outside the reception area during normal working hours. Boundary protection of the building includes operation of entry points, production of entry cards, etc.
82	Reception/switchboard	Total salary costs include social benefits, uniform and service agreements.
83	Mail	Total salary costs, postage, local transportation, operation and maintenance of the postal equipment.
84	IT service	Total salary costs, operation and maintenance of all equipment.
85	Moving	Total salary costs, transportation, extra maintenance and renovation.
86	Catering	Total salary cost to in-house and/or contract personnel, operation of automated machines, products and articles of consumption of the kitchen and rent of space.
87	Accessories/copying	Total salary costs, office and data accessories, internal and external copying, machines and equipment (rentals and service) papers, etc.
88	Administrative support	Total salary costs for in-house or support personnel.
89	Furniture and inventories	Total salary costs, purchasing and depreciation of furniture and diagnosis. Include rent of storage room.

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