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LCC-DATA

LCC-DATA

Life-Cycle-Costs in the Planning Process. Constructing Energy Efficient Buildings taking running costs into account

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WP4 - Deliverables D 16 & 17

Energy and LCC calculations – Case Study Buildings

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Definitions and Abbreviations

Definitions

Necessary definitions

Abbreviations

Cs	case study
D	deliverable (added by the number according to project contract)
EPBD	Energy Performance of Buildings Directive 2002/91/EC
Gs	German-speaking
IBI	“Immobilien Benchmark Institut” (Gs) - institute for benchmarking buildings, Kufstein University, Austria
kWh/m²a	kilo Watt hours per square meter and year
LCA	Life Cycle Assessment
LCC	Life Cycle Costs
LCCA	Life Cycle Cost Analysis
MOM	Management, Operation and Maintenance
NGF	“Netto-Grundfläche” (Gs), net floor area [m²]
PHPP	“Passivhaus-Projektierungspaket” (Gs), a method to calculate the energy performance of passive house buildings
RES	Renewable Energy Sources
RUE	Rational Use of Energy
WP	work package

1 Executive Summary

The work package 4 has two main objectives: to gain experience in the use of the LCC-DATA database itself for Life Cycle Cost Analysis (LCCA), and to attain the results from LCCA to provide input into decision making.

The framework of this WP 4 is given by the national rules according to the EPBD to calculate the energy demands and national rules/guidelines to calculate the LCC.

The aim of the completed work is to illustrate how energy and LCCA information can be effectively used by building owners, architects, planners and/or consultants. Furthermore the aim is to study how/whether key numbers or statistics can be used in early planning phase calculations, and whether the output is reliable enough for decisions at that point in time. This study is partly done by comparing results from early phase calculations and calculations later in the process when more specific information is available.

The relevant national rules, guidelines and tools for the energy calculations are introduced in chapter 3. For the level 1 LCC analysis, the created database of this project was programmed and used in the Czech Republic, Greece, Norway and Slovenia. In Austria the existing benchmark database (IBI-database) was used. In Germany an excel-file of refurbishment measures and costs for reducing the CO_2-emissions of buildings was the basis for the analyses within the WP 4.

The level 2 analysis was done according to national rules, which are also explained in chapter 3. Based on the reference values used, level 1 LCC calculations of case study buildings were performed. The comparison with the level 2 analysis according to national rules will demonstrate the accuracy of its estimations and therefore the relevance of the used key-figures.

It is justified that the development and expansion of the databases (LCC-DATA and IBI) will significantly increase the potential of its use in the study of LCC analysis. The current disadvantage of the databases is the limited number of building entries. The enrichment of the database with different buildings from private and public sector will provide validity to the cost indicators and increase the potential of its use in daily practice LCC calculations.

The performance indicators and the aims of the project concerning the WP 4 are:

1. 10 energy calculations per country
2. 20 LCC calculations per country
3. Energy saving potential shown in calculations in kWh/m²
4. Cost saving potential shown in calculations in €/m²/year
5. 3 building alternatives used in LCC and energy calculation

The achievement of those by the partners are shown in the following table.

Table 1: Performance indicators of LCC-DATA

performance indicator	**aim**	**Sintef**	**AEA**	**CityPlan**	**Berliner Energieagentur**	**CRES**	**BCEI ZRMK**
1	**10**	3	4	10	329	3	10
2	**20**	3	4	4	893 measures	3	22
3	**kWh/m²**	108-119	75 - 150	40-100	23 kg CO_2/m²/year	13-43	25 – 81 (heating) up to 200 (primary)
4	**€/m²a**	1	4.85	4.50	5	1.07-2.61	35
5	**3**	2	2	4	none	2	4

This report represents the national energy and LCC calculation results as a combination of the D 16 and D 17.

D 16	WP 4	Energy calculations	Report, data for LCC	50 pages – 1 to 2 pages per building	English and national languages	Building owners, architects, planners and consultants	All partners, leader AEA
D 17	WP 4	LCC calculations	Report	50 pages – 1 to 2 pages per building	national languages	Building owners, architects, planners and consultants	All partners, leader AEA

2 Introduction

The report presents the case study energy and LCC calculations based on the data collected in the WP 3 remit.

The experiences gained through use of the database itself is described by the partners of Norway, Czech Republic, Greece, and Slovenia, where the database is put into operation.

In Austria there already exists a benchmark database which includes the needed cost information, so this "IBI database" has been used.

In Germany a database to evaluate energy related measures for the refurbishment process of 329 public buildings was developed.

The experience with the prospective users collected from earlier workshop sessions is recorded in the created excel-sheet and is to be found in the "D 13 – National evaluation report", as well as in the "D 14 – Common evaluation report". The experiences made in the database handling phase within the workshops are to be found in the reports "D 18 – National workshops".

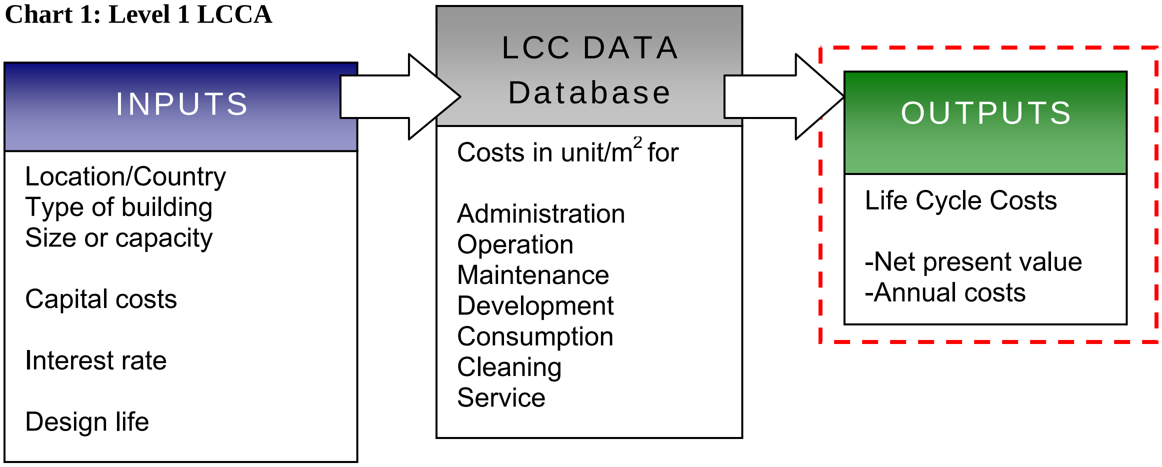
There are two main target groups for the use of the database: on the one hand, the building owners – they have a benchmark tool for their building stock, and on the other hand, the planners and architects - they have the possibility to use the generated key-figures out of the database for level 1 analysis, in order to facilitate LCCA in the early design stage, thus making for instructive input at the earliest possible stage.

With this view, the work was divided into two parts: in the first step several building owners were asked to describe their buildings by using the common building information sheet, including the cost data for these buildings (input data). Out of the collected data, key-figures were generated, expressed as per unit of surface (m^2) or per person.

In the second step, case study buildings were defined. The energy calculations were carried out by energy demand software tools used for calculating the energy performance of buildings according to the implementation of the EPBD or by simulation tools (such as TRNSYS), as well as national calculation methods.

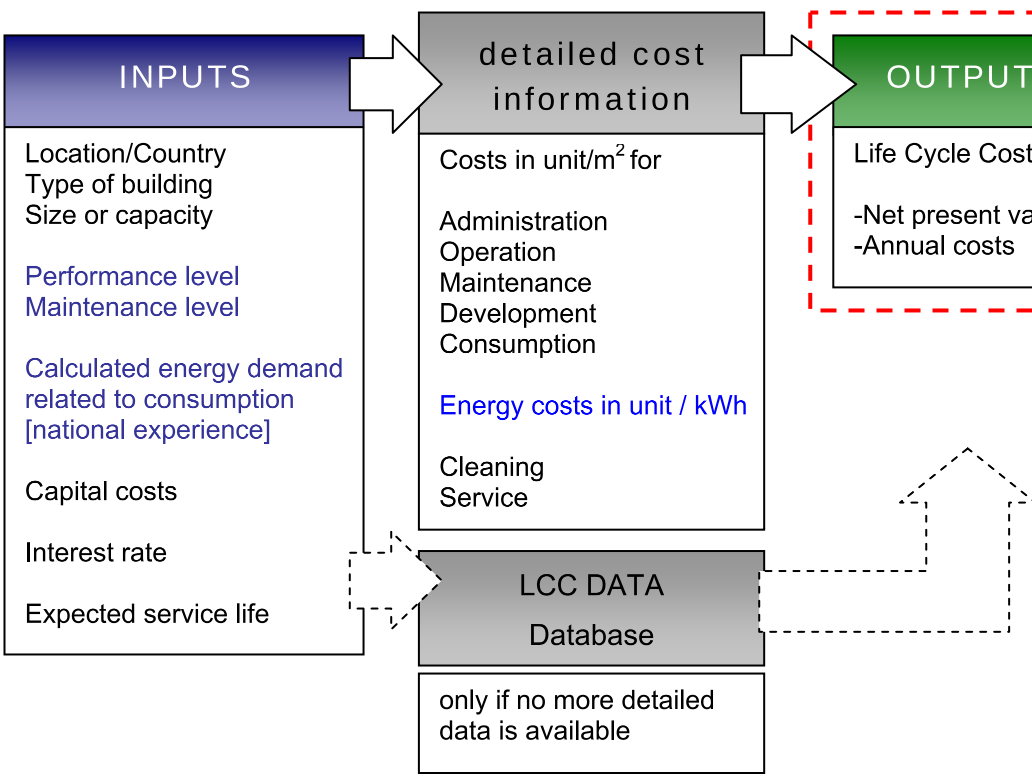
For the next stage, the level 1 LCC calculations were performed by using the key-figures generated from the database, based on collected building data (WP 3) as input parameters. LCCA is carried out on buildings at various stages of completion, on either new buildings or on refurbishment projects. LCCA could be done through use of statistic information (level 1), project specific information (level 2) or as a combination. The aim of the database is to generate key-figures to be used in the level 1 analysis in the early design stage, thus helping to prevent time-consuming activities, and to be comparable to the outcome of detailed level 2 analysis. Only a little input data would be required and the calculations of running costs over the lifetime are also easy to perform. The degree of detail, the required inputs and the calculated outputs are shown in chart 1. The calculated costs can then be used by the investor to assess the merit of a potential project.

Chart 1: Level 1 LCCA



The second level of analysis (level 2) is an effective tool which can be used in the planning phase. Available data at this stage is more detailed and project-specific. Hence, the accuracy of estimates improves and enables investors to choose between specific development alternatives (e.g. type of heating system). Level 2 LCCA comes into play when project alternatives that reach the same level of performance but differ with respect to capital and running costs have to be compared. A short term view often leads investors to choose the least capital intensive option, whilst the use of more expensive material could lead to substantial savings over the lifetime of the project. The level 2 analyses were carried out according to national rules (for details see chapter 3).

Chart 2: Level 2 LCCA



3 National frameworks

3.1.1 Norway

3.1.1.1 Energy Calculations

Technical regulations under the “Planning and Building Act 1997” define the requirements for energy in buildings. The regulations define two different methods for documentation that the requirements are met, either by a check list of measures or by calculations. In 2007, the regulations for energy efficiency were revised in Norway. The regulation is related to the net energy demand of a building (no requirement on delivered energy or on primary energy). The net energy demand threshold fixed by the regulation includes all energy use, that is: heating, cooling, ventilation, domestic hot water, fans and pumps, lighting and electrical appliances.

When verifying the compliance with the regulations, net energy demand has to be calculated with standardised parameters according to “NS 3031: 2007 Calculations of energy performance of buildings. Method and data.”.

The requirements are that the energy demand, including heating, ventilation, lighting, and equipment, are calculated by use of standardised values for indoor temperature, effect of equipments, time of use etc, and outdoor temperature/climate. This is done to ensure that the calculated values are for the building performance, and not for the use.

When studying different technical solutions as the basis for decision making, the energy demand with the specific information for climate, use etc. has to be calculated.

3.1.1.2 LCC calculations

The standard “NS 3454: 2000 Livssykluskostnader for byggverk. Prinsipper og struktur” describes the process for calculating LCC, the input/output, and the cost classification.

The cost classification is used in the calculation tool LCProfit, and in the national database for benchmarking. It is started a process for revising the standard, where the Nordic proposal is one of the starting points.

3.1.2 Czech Republic

3.1.2.1 Energy Calculations

Since the year 2000 the Czech Republic has regulated energy consumption for heating and ventilation in buildings. The obligation on the owners of the buildings to meet minimum energy requirements for heating is stipulated by the "Energy Management Act No 406/2000 Coll." which came into effect on 1st January 2000. The minimum requirements and the way in which the owner of the new building or a building undergoing major reconstruction are stipulated in the "Decree No. 291/2001 Coll.", (replaced by "148/2007 Coll. from 07/2007", Decree of the Ministry of Industry and Trade laying down Energy intensity of buildings) were issued pursuant to this act. The Decree determines the particular energy efficiency limit values for heating and ventilation to be met and also a methodology for calculating the energy consumption and relevant Czech technical standards.

The achievements of the EPBD implementation in the Czech Republic can be summarised as follows: from the 1st January 2009 on, all new or reconstructed buildings in the Czech Republic await a fundamental change. The EPBD is incorporated into Czech legislation in "Act No. 406/2000 Coll.", on energy management and related legislation such as in all other EU Member States, compulsory certification of the energy performance of buildings will be implemented in the Czech Republic for all buildings both in the public and private sector.

In "Decree No. 148/2007 Coll." (valid since 1st July 2007) the so-called Energy Performance Certificate of buildings was defined in the form of an energy label with levels from A to G based on the state of the building. Objects in category A (highly economical, e.g. so-called passive buildings) up to C (satisfactory) – these should comply with the newly established requirements; buildings with D up to G (unsatisfactory to highly unsatisfactory) do not meet parameters of the new implemented standards.

3.1.2.2 LCC calculations

In the Czech Republic there is not any directive for determining life cycle costs.

For LCA, energy, emissions and costs analysis is used the software "GEMIS".

3.1.3 Greece

3.1.3.1 Energy Calculations

In order to define the energy demand of the selected case studies, TRNSYS (Transient System Simulator) software was used, which is for energy modelling and it calculates the heating and cooling demand on monthly basis, as well as the internal temperatures in each defined thermal zone.

The aim was to use the national calculation method of the EPBD implementation but it is not officially developed and approved by the national legislative framework. The technical and legislation document regarding EPBD implementation was completed in December 2008 and published for public discussion. Since then, no final document is produced; therefore it is not feasible to use national rules to calculate the energy performance of buildings for the selected case study buildings.

3.1.3.2 LCC Calculations

LCC in the construction sector is a field of continuous interest growing, due to the high potential of energy and resources management throughout a building lifetime. There is no legislative framework that imposes LCC calculations in Greece; however Public Private Partnership (PPP) and Energy Service Companies (ESCOs) approve that need and sets LCC as a principle parameter in the building industry.

Operational cost breakdown does not exist in Greece as described in “D4 - Classification system for facility management information” and regarding cost categories, there is no national cost classification system for LCC purposes. Therefore, cost data has been collected according to the developed database format. In addition to that, there is no national calculation system for LCC analysis, therefore LCProfit software tool has been used. Results are to be found in chapter 3.1.3. For Level 1 approach, cost information is taken from the LCC-DATA database from the current cost entries. As this database is new at national level, it is a significantly time consuming process to categorise and collect costs from building projects (public and private).

Concluding, the study aims to minimise LCC, but mainly aims to make building owners and users aware of the financial consequences of some of their decisions in terms of maintenance and operational costs. The EPBD implementation at national level is increasing awareness on energy costs, therefore this supplementary work of management the maintenance and operational costs will enrich the background for the LCC calculation processes.

3.1.4 Slovenia

3.1.4.1 Energy Calculations

The energy calculations are done based on the EPBD regulation in Slovenia. The building regulation was accepted in September 2008 ("PURES 2008" regulation on energy efficiency of buildings), additional regulations focussing on feasibility studies of alternative energy systems and energy certification were issued in April 2008 and January 2009, respectively.

Calculation of energy performance of buildings for the purpose of showing the compliance with the minimum requirements is done (a) based on "SIST EN12831:2004" for specific heating power demand (W/m^3) and based on "VDI 2078:1996" or "ASHRAE" for specific cooling power demand (W/m^3); or (b) while for checking the energy use of a building the calculation can be done either by a simplified method (before mentioned (a)) or by "SIST EN ISO 13790" (details are available in regulation on efficient use of energy in buildings, since September 2008).

For the purpose of energy certification of buildings the "SIST EN ISO 13790" procedure was upgraded with the necessary national framework (in proposal for regulation for energy performance of buildings). Currently, the respective software is being developed by various market players (one tool finished, the next one in progress). Validation of software tools can be done by the ministry, as defined in the drafted regulation for energy certification of buildings.

The case studies in this report have the energy demand calculated according to "SIST EN ISO 13790" and national boundary conditions as well as RES and RUE targets (min. requirements). For the energy calculation various tools (based on the above mentioned CEN EPBD standards) were used: i.e. excel worksheet for EPBD based energy calculation and PHPP tool.

3.1.4.2 LCC calculations

In Slovenia LCC calculations are in general voluntary, but in specific situations decision making has to be supported with LCCA, i.e. public investments have to be justified with the investment documentation:

- Investment documentation in case of public investments (Decree on unique methodology for preparation and treatment of investment documentation; "Uradni list (Ur.l.) RS, nr. 60/2006" from June 9th, 2006).

Public private partnership projects, contracting projects and green public procurements are the most frequent situation when LCC comes on the agenda. The details are defined in the following documents:

- Rules on the content of the eligibility of execution of a project according to the model of public private partnership ("Pravilnik o vsebini upravičenosti izvedbe projekta po modelu javno zasebnega partnerstva. Ur.l. RS, št. 32/2007").

- In December 2006 a new Public Procurement Act ("ZJN-2") explicitly introduced the possibility to include green criteria in the call for tenders' documentation. Energy and environmental criteria were brought forward – not as an obligation, but as a (recommended) possibility in contract award procedures. This Public Procurement Act ZJN-2 allows: (a) the lowest price based procurement and (b) the economically most viable offer based on more comprehensive criteria. If (b) is used, then investment must have minimum 40% influence (Article 48); while other criteria may have up to 60% influence, (where criteria like: quality of product, service, building, technical benefits, aesthetic and functional features, energy and environmental features, cost benefit, running costs may be used for evaluation). This is the legal background for introducing LCC as a tool providing comprehensive information on the economic performance of energy efficient buildings.

In general financial and economic evaluation requested in the regulation does not explicitly require detailed evaluation of different RES and RUE building scenarios. LCC is directly required only in

- EPBD Art. 5 Regulation on obligatory feasibility studies of alternative energy systems ("Uradni list RS, nr. 35/2008" from April 9th, 2008).

3.1.5 Austria

3.1.5.1 Energy Calculations

The implementation process of EPBD was finished in 2008 and according to this, the national rules to calculate the energy performance of buildings has been used for the case study buildings.

There are two guidelines of the Austrian Institute of Construction Engineering which are mainly used in Austria:

- Energy conservation and thermal protection – "OIB-300.6-038/07" ("Richtlinie 6 Energieeinsparung und Wärmeschutz", Gs)
- Energy management of buildings – „OIB-300.6-039/07" ("Leitfaden energietechnisches Verhalten von Gebäuden", Gs)

The legal regulations in Austria concerning the energy performance of buildings are defined in Austrian Standards ("ÖNORM", Gs):

- Determination of areas and volumes of buildings –"ÖNORM B 1800"
- Thermal protection in building construction – "ÖNORM B 8110"

These are supported by Austrian Standards which are to be finalised (in process, therefore "VORNORM", Gs)

- Energy Certificate for buildings – "VORNORM H 5055"
- Energy performance of buildings, Heating systems – "VORNORM H 5056"
- Energy performance of buildings, Ventilation and Air Conditioning – "VORNORM H 5057"
- Energy performance of buildings, Cooling systems – "VORNORM H 5058"
- Energy performance of buildings, Lighting – "VORNORM H 5059"

All these regulations and guidelines are considered in the diverse calculation programmes used in Austria.

There is an MS Excel programme, which is publicly available via the website of the Austrian Institute of Construction Engineering. This programme was used by the Austrian Energy Agency for the energy calculations of the case study buildings.

The demands calculated for heating and/or the sum of all electricity demand (ventilation, cooling, lighting, auxiliary) were multiplied by the primary energy factors (gas = 1.36; district heating = 0.3; electricity UCPTE mix = 3.31) and then multiplied by the CO_2 -emissions equivalent (gas = 0.277; Vienna district heating = 0.2; electricity UCPTE mix = 0.617 [kg/kWh]) to get the CO_2 –emissions [kg].

3.1.5.2 LCC calculations

There are the following standards for the declaration of cost categories:

- Building costs – cost breakdown – "ÖNORM B 1801-1"
- Building costs – user costs – "ÖNORM B 1801-2"
- Statement of operational costs of buildings with rented and condominium apartments – "ÖNORM A 4000"
- Project management in construction – characteristic values – "ÖNORM B 1801-3"

Additionally there is one "ÖNORM" handling real estate evaluation:

- Real estate evaluation – "ÖNORM B 1802"

The content of this "ÖNORM B 1802" is based on the Real Estate Valuation Law. The most used valuation method for office buildings are the income approach, and the present value method. Outpayments are subtracted from incoming payments (rent). Running costs[1] (outpayments) are calculated based on percentage default values. Discounting is used to determine the building´s value in a comparable way. The Austrian Energy Agency used this approach based on "ÖNORM B 1802" for the level 2 analysis of the case study buildings.

For the level 1 analysis the key-figures were generated from the IBI-database, which at the moment includes 40 Austrian buildings (18 offices).

The results of the Austrian energy and LCC calculations are to be found in chapter 4.5.

[1] administration, operation, maintenance, development, consumption, cleaning and service costs

3.1.6 Germany

The Senate Department for Urban Development increases their activities concerning energy efficiency and climate protection. Especially the development of the considerable saving potentials in properties owned by the Senate Department is foreseen through comprehensive refurbishment activities. Thus, a huge contribution for the implementation of the energy efficiency action plan and for the attainment of the aim for the reduction of CO_2-emissions will be achieved.

A plan of measures for the energetic refurbishment has been developed for the buildings managed by the Senate Department for Urban Development, which is planned to lead to a reduction of CO_2-emissions of at least 30 percent. A comprehensive plan of measures has been developed on the basis of object-specific energy concepts. The result of the plan of measures are realistic statements on effective measures, their technical feasibility, needed investments and the energetic and financial saving potentials – and, thus, the energy related LCC.

Therefore seven experienced engineering consultants have been assigned by the Senate for the external planning services. The controlling, co-ordination and quality assurance was monitored by the Berlin Energy Agency. Moreover the Agency took part in the development of the measure plan and especially in the evaluation of the LCC of the different measures.

4 The case study buildings

In the following chapter, the analysed data of 15 case study buildings are introduced by the corresponding partners.

The case studies were analysed and used to provide the energy calculations, as well as level 1 and 2 LCC analyses. These specific cases are chosen to illustrate the life-cycle costs related to the main categories of buildings (e.g. offices, hospitals, schools, etc.) with focus on the installed systems (e.g. heating and cooling applications, ventilation, etc.).

4.1 Case studies Norway, Sintef

4.1.1 Aims and objectives

The energy and LCC calculations were done for a large Norwegian public builder, Statsbygg..

The goal of the energy calculations was to use them as basis for future use phase costs, and to identify potential areas of savings (and not specific goals of energy efficiency). The energy calculations were done at pre-project stage. Statistics from "ENOVA SF 2004" (public enterprise owned by the Royal Norwegian Ministry of Petroleum and Energy) show that the average total energy use for college buildings is 246 kWh/m^2 (which must not be seen as an energy goal). The requirement due to the energy legislation (2007) is 180 kWh/m^2 for university/college buildings. This requires standardised temperature and use conditions. The energy calculations for the two case studies are based on energy legislation from 1997.

The primary goal is to use the LCC calculations as a basis for future rent calculations. Calculations on both level 1 and 2 are carried out for both cases. The sources for input of data vary and are described for each case.

4.1.2 Case Study Building N° 1, Vestfold University College

Picture 1: Vestfold University College

Case study N° 1 is a college building, the "Vestfold University College", situated in Bakkenteigen, Norway. The project period is 2008-2010. The construction is a combination of steel and concrete elements while brickwork, wood and glass were used in the facades. The new building will host the teacher training department and common auditoriums, smaller teaching rooms, a library and common areas for the college.

4.1.2.1 Energy calculation results

The energy calculations for case study N° 1 are based on two sources: 1) specific energy consumption for a similar college building in the same geographic area and 2) data on energy effect calculated in the pre-project phase of case study N° 1. The specific energy consumption (total 194 kWh/ m^2 per year) given for the similar college building is assumed to be representative also for case study N° 1. Except for heating, the distribution on the different posts is based on given experience numbers from the LCC tool. The results are shown in Table 2.

Table 2: Energy calculations for Norwegian cs N° 1

case study N° 1	**Thermal**		**Electricity**		**TOTAL PR year**	
	kWh/m² a	**kWh/a**	**kWh/m² a**	**kWh/a**	**kWh/m²a**	**kWh/a**
Heating	50	951,060	25	396,275	75	1,347,335
Ventilation	25	396,275	20	317,020	45	713,295
Domestic	15	237,765	0	0	15	237,765
Lighting		0	15	237,765	15	237,765
Equipment		0	7	110,957	7	110,957
Cooling, vent.		0	10	158,510	10	158,510
Process cooling		0	25	396,275	25	396,275
Sum building	**100**	**1,585,100**	**102**	**1,616,802**	**192**	**3,201,902**
Street heating	20	30,000	2	3,000	22	33,000
Outdoor lightning			1	500	1	500
Sum total	**101**	**1,615,100**	**102.5**	**1,620,302**	**194**	**3,235,402**

The total calculated energy demand per year was calculated to be 194 kWh/m^2. The heating system consists of radiators and floor heating, supplied by central heating based on oil and electricity boilers. The specific HVAC calculations were not available and would have given a more correct picture of the energy calculations.

4.1.2.2 LCC calculations

The main source of data for the LCC calculations is the pre-project material.

The project costs are calculated in the pre-project phase, first in 2003 and then recalculated later in the buildings process (2006). Both 2003 and 2006 calculations are used in level 1 calculations. The specific building area and total amount of students and teachers (information from the pre-project) are basis of level 1 calculations as well.

One level 2 calculation is carried out. The calculation is based on project costs from 2006. Further input in the level 2 calculation are the energy and cleaning costs (project specific information), together with some of the building parts for maintenance. Some general input data on case study N° 1 are shown in Table 3. The level 1 and 2 calculations are given in Table 4.

Table 3: General input data on Norwegian cs N°1.

case study N° 1	*General*	Comments
Building information		
Name of building	Vestfold university college	
Location/Country	Norway	
Type of building	college	New construction
Construction characteristics		
Gross area [m^2]	15,851	
Heated floor area [m^2]	10,497	
Non heated floor area [m^2]	1,000	Parking area
Performance level		
Maintenance level		
Operation and main installations		
Building management System	central control and monitoring system	
Main building material	steel and concrete	
Type of heating system	radiators and floor heating	supplied by central heating based on oil and electricity boilers
Heating control / regulation	central control and monitoring system	
Domestic water heating	supplied by central heating unit	
Type of cooling system	central cooling unit for cooling of ventilation air, local cooling (rooms with high internal loads)	

Table 4: Level 1 and 2 calculations on Norwegian cs N° 1

Capital Costs	Level 1 (project costs 2003) [UNIT: NOK/m^2]	Level 1 (project costs 2006) [UNIT: NOK/m^2]	Level 2 (project costs 2006) [UNIT: NOK/m^2]
Project costs	1,498	2,106	2,106
Remaining costs	0	0	0
Running Costs (excl. energy) [unit/year]			
Administration	40	40	245
Operating	500	500	808
Maintenance	90	90	100
Development	20	20	2
Cleaning	(included in operating)	(included in operating)	82
Total cost per year			
	2,148	2,756	3,343
Energy Costs			
Total energy demand	(included in operating)	(included in operating)	162
Heating	(included in operating)	(included in operating)	63
Cooling	-	-	
Electricity	(included in operating)	(included in operating)	99

For level 1, the project costs are calculated in the years 2003 and 2006. The 2006 project costs are used as the basis for the level 2 calculation. The running costs used in the level 1 calculations is not adjusted for inflation (2006 to 2003), and are therefore not directly comparable.

The project costs increase considerably from the first pre-project phase in 2003 to the second phase in 2006 (given in NOK/m^2), the difference is 40 %, while the increase due to inflation in the period would have given a project cost of 1.714 NOK/ m^2. One reason for the increase is the fact that more specific information on the construction itself, as well as for heating, ventilation and sanitation etc. was available in 2006, but also that topics and qualities are added during the process..

In addition the project costs from 2006 are the input to the level 2 calculation. In the level 2 calculations, information from the pre-project is included in calculating cleaning costs, energy costs and maintenance costs. Development costs are set low due to a lack of information about this. The total costs per year increase considerably from the level 1 calculation. In particular the operating costs are considerably higher. The input data for the energy costs are not specific for case study N° 1 and are based on a specific energy use from a college in the same geographic area. The calculated energy demand in the pre-project is probably lower.

In the level 2 calculations it is used a combination of key numbers on more detailed level and project specific costs. More use of project specific cost throughout the process would give more reliable results.

For Statsbygg the use of information out of the level 1 were regarded as sufficient for the decision making at that stage, asking for budgets to continue the process, while LCC calculation for rent calculations, seems not sufficient compared to the level 2 calculations.

4.1.3 Case Study Building N° 2 Sogn og Fjordane University College

Picture 2: Sogn og Fjordane University College

The second case study is also a college building, the new central building connecting the existing buildings at the "Sogn og Fjordane" University College in Sogndal, Norway. The project has so far not been realised. The materials to be used are concrete and glass. The new building has the intention of connecting the existing college buildings, and will consist of auditoriums and class rooms, offices and administration premises, cafeteria and common areas.

Different sources are used to gain information and input for the energy and LCC calculations, and data was mostly taken from the pre-project period.

4.1.3.1 Energy calculation results

For case study N° 2, the energy calculations are done by the HVAC consultant within the pre-project phase, by using the Norwegian programme "Energi i bygninger" (present programme called "SIMIEN", www.programbyggerne.no). The data provided from the pre-project are the primary input of the energy and power calculations in the LCC calculations. The energy simulation is based on constant ventilation. The total calculated energy demand per year is 119 kWh/m^2, annual total energy demand 904,918 kWh. The results are shown in Table 5. The heating system is radiators and the energy calculations are done in accordance with the 1997 legislation in Norway.

Table 5: Energy calculations of Norwegian cs N° 2

based on constant ventilation

case study N° 2	**Thermal**		**Electricity**		**TOTAL PR yr**	
	kWh/m^2 a	**kWh/a**	**kWh/m^2 a**	**kWh/a**	**kWh/m^2 a**	**kWh/a**
Heating	22	164,954	0	0	21.7	164,954
Ventilation	11.7	88,821	21.3	162,172	33.0	250,993
Domestic	11.47	86,823	0	0	11.4	86,823
Lighting		0	38.9	296,200	39.0	296,200
equipment		0	9.3	70,380	9.3	70,380
Cooling, vent.		0	0.04	318	0.04	318
Process cooling		0		0	0	0
Sum building	**44.8**	**340,598**	**69.6**	**529,070**	**114.4**	**869,668**
Street heating	150	35,250		0	150	35,250
Outdoor lightning				0	0	0
Sum total	**49.4**	**375,848**	**69.6**	**529,070**	**119**	**904,918**

The entrance hall has a glass roof. The project owner wanted an alternative energy calculation with a fixed roof instead of glass roof, giving a calculated difference of 5,500 kWh per year. This decreases the energy demand with 1 kWh/m^2 a, to a total of 118 kWh/m^2 a. This is not further used in the LCC calculations, due to the differences in project costs and maintenance costs are not known. The energy calculations were also done for variable ventilation. This reduced the total energy demand to 824,699 kWh/year (108 kWh/m^2 a) and is used to make an alternative LCC calculation and to study the difference in operating costs in level 2.

4.1.3.2 LCC calculations

The general project information is shown in Table 6. The level 1 calculation in this case is done by using key data from the LCC tool, combined with the correct area for the buildings, number of employees and students using the building and project costs. In the tender, the Statsbygg has given a proposal for the total project costs. These costs are used as input in both level 1 and 2 calculations. The actual project costs are not given, but are close to the ones in the tender. On level 1, the total costs per year are calculated to 13,891,446 NOK.

In the level 2 calculations, the project costs are the same as used in level 1. Following this, further adjustments are done based on information from the pre-project material. This includes cleaning, waste handling, energy costs, maintenance and development. The costs used are a combination of key number on detailed level (for instance costs for cleaning different surfaces (NOK/ m^2), and project specific costs.

When using variable ventilation instead of constant ventilation, the operating costs change. The results from level 1, level 2 (constant ventilation) and level 2 (variable ventilation) are shown in Table 7.

The total costs per year for level 1 are calculated to 1,827 NOK/m^2. For level 2 with constant ventilation, the costs are 1,840 NOK/m^2. The main difference is in the administration costs, which are significantly higher, and including the property taxes might be a reason for this. The maintenance costs are lower because building materials with low maintenance costs are chosen in the case. The operation costs are slightly lower, and lowest with variable ventilation.

In this project, the level 1 calculation seems to be suitable as decision support in the early project stage, and also gives an estimated rent. Calculation with constant and variable ventilation gives the public builder information on how this impacts the operation costs. Decisions concerning the cost covering rent is taken on the basis of the real project cost and information of the finalised building (as built).

Table 6: General input information about Norwegian cs N° 2

case study N° 2	*General input***	Comments
Building information		
Name of building	Sogn og Fjordane University College	
Location/Country	Sogndal, Norway	
Type of building	College	Extension, not realised
Construction characteristics		
Gross area [m^2]	7,604	
Heated floor area [m^2]	5,678	
Non heated floor area [m^2]	2,625	parking
Performance level		
Maintenance level		
Operation and main installations		
Building management System		
Main building material	Concrete	
Type of heating system	Radiators	
Heating control / regulation	Central control and monitoring system	
Domestic water heating	Supplied by central heating unit	
Type of cooling system	Chilled beams	

Table 7: LCC calculations for level 1 and 2 for Norwegian cs 2

Level 2 is calculated with constant and variable ventilation.

Capital Costs	Level 1 [UNIT: NOK/m^2]	Level 2, constant ventilation [UNIT: NOK/m^2]	Level 2, variable ventilation [UNIT: NOK/m^2]
Project costs	1,177	1,177	1,177
Remaining costs	0	0	0
Running Costs (excl. energy)	[UNIT: NOK/m^2]	[UNIT: NOK/m^2]	[UNIT: NOK/m^2]
Administration	40	101	101
Operating	500	439	431
Maintenance	90	53	53
Development	20	24	24
Cleaning	(included in operating)	46	46
Total cost per year	[UNIT: NOK/m^2]	[UNIT: NOK/m^2]	[UNIT: NOK/m^2]
	1,827	1,840	1,832
Energy Costs	[UNIT: NOK/m^2]	[UNIT: NOK/m^2]	[UNIT: NOK/m^2]
Total energy demand	(included in operating)	92	86
Heating	(included in operating)	35	31
Cooling	0	0	0
Electricity	(included in operating)	57	55

4.2 Case studies Czech Republic, CityPlan

4.2.1 Case study N°1 Elementary school "Vrchlickeho", Liberec

The elementary school in Liberec is made of brickwork and consists of a main building and gym. The supplier of heat is the municipal heat plant Liberec. The total energy demand is about 800 MWh per year.

Table 8: **Energy consumption of Czech cs N°1**

Energy consumption	**kWh/a**	**kWh/a m^2**	**%**
Lighting	25,926	5.0	3.3%
Motors	5,933	1.1	0.7%
Heat device	57,630	11.1	7.2%
Other	2,144	0.4	0.3%
Heating	648,494	125.1	81.6%
Water heating	54,889	10.6	6.9%
Total	**795,016**	**153.3**	**100.0%**

Table 9: **General information about the Czech cs N°1**

case study N° 1	***General***	Comments
Building information		
Name of building	elementary school Vrchlickeho	
Location/Country	Czech Republic	
Type of building	elementary school	old building
Construction characteristics		
Gross area [m^2]	5,185	
Heated floor area [m^2]	8,185	
Non heated floor area [m^2]	0	
Performance level		
Maintenance level		
Operation and main installations		
Building management System	-	
Main building material	brickwork	
Type of heating system	radiators	district heating (municipal heat plant)
Heating control / regulation	central control	
Domestic water heating	supplied by central heating unit	
Type of cooling system	-	

In the level 1 calculation the actual state of building costs and energy consumption is used. In level 2 the state of costs and energy consumption after the reconstruction of the building is used. Reconstruction includes insulation of walls, changing windows and installation of thermo regulation valves for heaters. The costs for the reconstruction is 4,220,000 Czech Crowns. After 15 years there will be needed an investment of 380,000 Czech Crowns for changing valves.

Table 10: **Cost analysis of the Czech cs N°1**

Capital Costs	Level 1 [UNIT: CZK/a]	Level 1 [UNIT: CZK/m² a]	Level 2 [UNIT: CZK/a]	Level 2 [UNIT: CZK/m² a]
Project costs	-	-	4,220,000	814
Remaining costs	0	0		0
Running Costs (excl. energy)	[UNIT: CZK/a]	[UNIT: CZK/m² a]	[UNIT: CZK/a]	[UNIT: CZK/m² a]
Administration	9,243,081	1,783	9,243,081	1,783
Insurance	3,217,024	620	3,217,024	620
Operating	4,093,595	790	4,093,595	790
Maintenance	-	-	-	-
Development	-	-	-	-
Cleaning	-	-	-	-
Energy Costs	[UNIT: CZK/a]	[UNIT: CZK/m² a]	[UNIT: CZK/a]	[UNIT: CZK/m² a]
Total energy costs	1,371,000	264	1,064,000	205
Heating	1,051,000	203	744 000	143
Electricity	320,000	62	320 000	62

For the LCC calculations the following values were used:

Discounting rate: 5 %

Lifetime of capital cost: 30 years

Chart 1: Cumulated present values of costs for Czech cs N°1

(capital costs = price of reconstruction, running costs = energy costs)

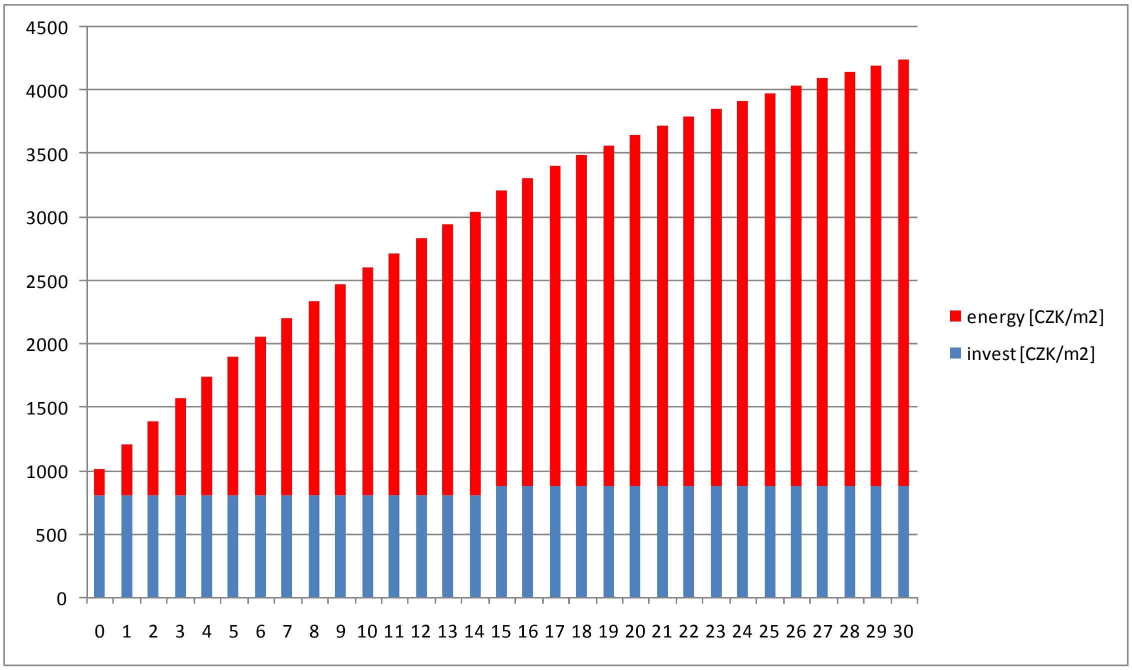


Chart 2: Cash flow without accumulation

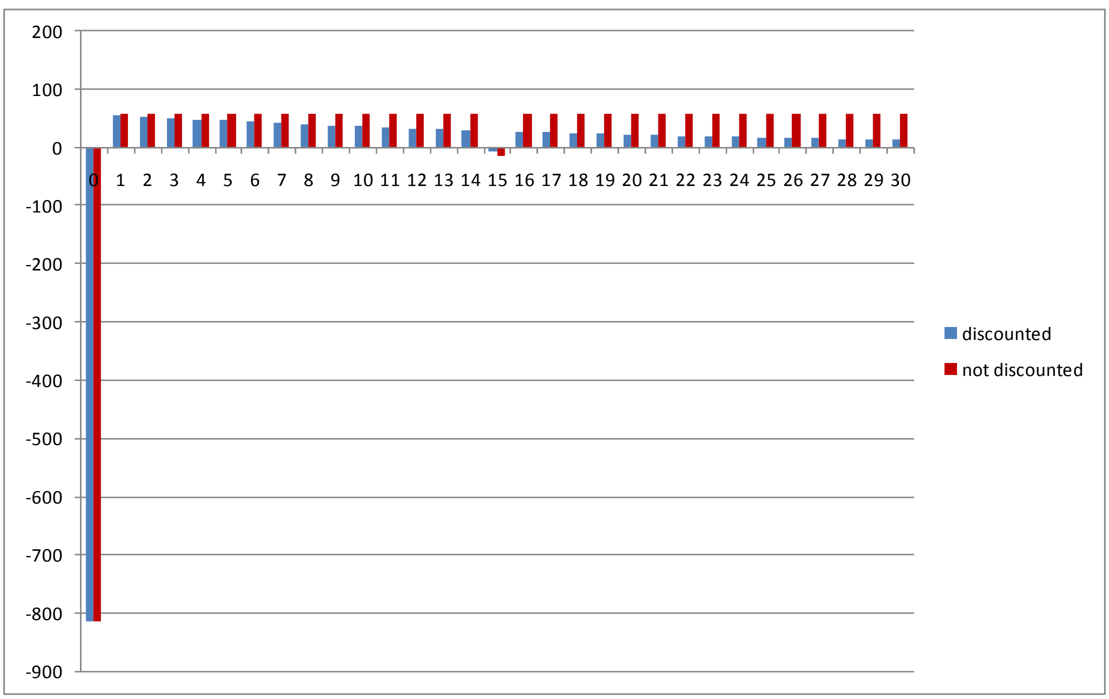
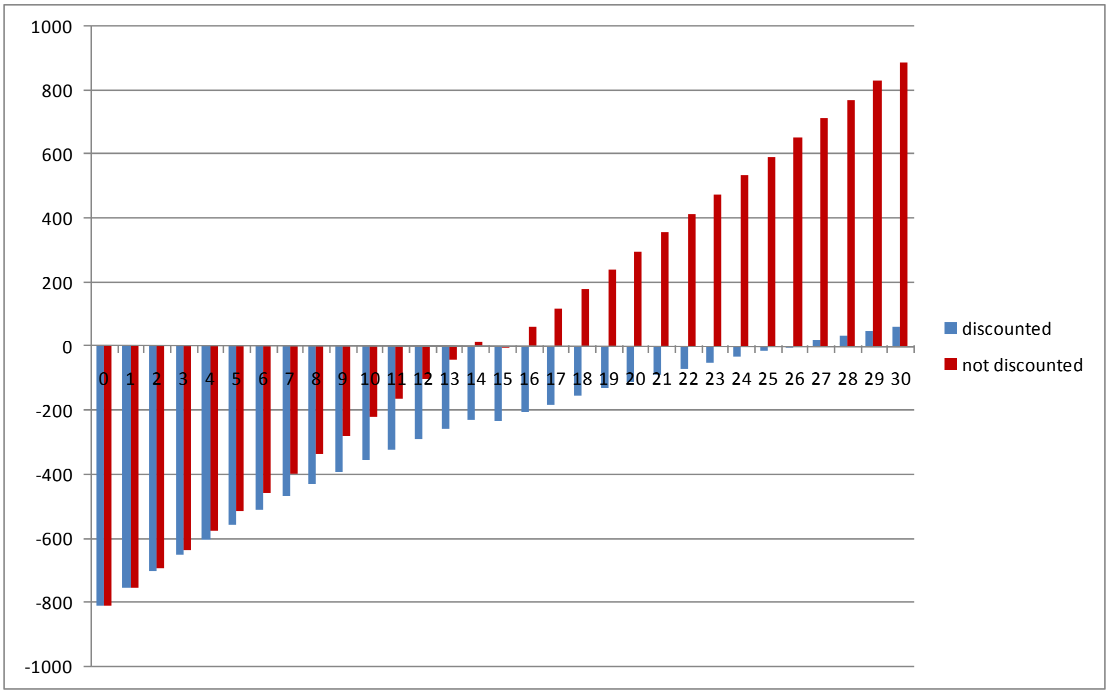


Chart 3: Cumulated cash flow



4.3 Case studies Greece, CRES

4.3.1 Aims and objectives

The aim of this study is to test the effectiveness and use of the LCC database, even at a preliminary stage of cost data collection.

Main focus is given on office buildings as most of the data collected is from this type of use. All case studies are existing buildings and analytical cost data has been collected. The reason of selecting these buildings was due to the post occupancy cost data availability, aiming to assess the use of the database developed in LCC-DATA project compared to the available LCC software tools.

The energy calculation aimed to show the potential of energy saving with different scenarios of envelope upgrade. Interventions on the building envelope would decrease the energy demand and subsequently the consumption of the building (applying energy efficiency measures) and predict the decrease of future building energy costs. The energy demand was calculated with TRNSYS simulation software as no national software exists.

The LCC calculation aimed to predict the cost saving in the case study buildings' lifetime, testing different alternatives, mostly on envelope upgrade. Calculations on both level 1 and level 2 have been carried out for all case studies.

4.3.2 Case Study Building N° 1, CRES main office building

Picture 3: West façade and main entrance of the Greek cs N°1

Case study N° 1 is the main office building of CRES, which is located in the suburbs of Athens. The building was constructed in 1985 and used as residency until 2002, when it was converted into office use. The main interventions on the building during that change of use were the new internal office areas, windows replacement from single to double glazing and fan coil replacement – 27 in total (dated 2003). After 7 years of occupancy, an energy efficiency upgrade is taking place, with external insulation on the building fabric, as an aim to improve its energy performance and energy costs.

The main construction of the external walls is brickwork with concrete structure elements and aluminium double glazed windows and sliding doors, and the roof is tiled.

The building accommodates office areas, a reception area, a lecture room, 2 meeting rooms and WCs. It is a 2 storey building with vertical circulation by an internal staircase.

4.3.2.1 Energy calculation results

Energy audit and energy calculation have been carried out by CRES in order to assess the potential of energy efficiency and also to compare the actual performance of the building with the calculated methods. The program used for energy simulation is TRNSYS. The table below shows the thermal and electricity consumption of the building on annual basis.

Table 11: Energy consumption for the Greek cs N°1

Figures for CRES - year 2007

case study N° 1	**Thermal**		**Electricity**		**TOTAL PR year**	
	kWh/m^2 a	**kWh/a**	**kWh/m^2 a**	**kWh/a**	**kWh/m^{2}a**	**kWh/a**
Heating	81.4	115,000	150	212,760	231.4	326,736
Cooling			82	115,560	82	115,560
Lighting			17.8	25,200	17.8	25,200
Sum building	**81.4**	**115,000**	**249.8**	**353,520**	**331.2**	**467,496**

From the analysis of the total energy consumption for November 2007, it appears that 55.8% corresponds to electricity and 44.2% to oil consumption. In terms of electricity distribution, a percentage of 42.4% corresponds to the office equipment while 15% correspond to lighting consumption.

The above shown data has been collected and analyzed from the building energy audit. From the TRNSYS simulation analysis, the following results appear:

Table 12: Energy demand[2] for the Greek cs N°1

Energy	Energy demand per m^2 (kWh/m^2)	CO_2 per m^2 (kg/m^2)	CO_2 per person (to/person)
Annual energy for heating	185.84	49.50	0.81
Annual energy for cooling	48.35	41.09	0.43

According to the submitted national legislation document for the EPBD implementation ("FEK 89", Legislation document 3661/2008), energy consumption for average new office buildings for climatic zone B (includes Athens area) is estimated[3] to 100-135 kWh/m^2 while the existing building stock is 155-175 kWh/m^2.

The excessive energy consumption is mainly due to the poor envelope construction, in which no insulation (walls and roof) leads to significantly high thermal losses and

[2] The figures are energy demand and not energy consumption. It does not include the energy consumption for lighting and office equipment. These factors plus the post occupancy management and behavior pattern are the main reasons for differences in the figures of the two tables 11 and 12.

[3] These are not approved figures, the document is under assessment and figures might change. However, as reference values, it can be concluded that this case study office building is rated Z, showing the high potential and need for energy saving measures.

subsequently increased energy consumption for heating. Thermal bridges are also a main parameter for high thermal losses, revealed from the thermographic analysis of the energy audit.

The main alternatives analyzed in terms of energy efficiency improvement are the following:

- SCENARIO 1: External wall insulation: 22.9% energy saving for heating (decreased to 143kWh/m^2), 0,3% energy saving for cooling (decreased to 48 kWh/m^2)
- SCENARIO 2: External shading improvement: 24.9% energy saving for cooling (decreased to 36 kWh/m^2)

4.3.2.2 LCC calculations

The main source of data for the LCC calculations are the cost information collected for the building (for the LCC-DATA database purposes). In the case of missing figures in the collected data, average market costs and estimates are used.

Level 1 calculations are derived with cost information from LCC-DATA database and level 2 calculations are derived using LCProfit software. Input data on the LCProfit software is mainly from costs collected and average national statistic cost data.

Some general input data on case study N° 1 are shown in Table 13. The level 1 and 2 calculations are given in Table 14.

Table 13: General input data on Greek cs N°1.

case study N° 1	***General***	Comments
Building information		
Name of building	CRES main building	
Location/Country	Greece	
Type of building	office	existing building
Construction characteristics		
Gross area [m^2]	1,220	
Heated floor area [m^2]	1,220	
Non heated floor area [m^2]	0	no parking area
Performance level	medium	
Maintenance level	medium	
Operation and main installations		
Building management System	localised manual switch, heating and cooling control	
Main building material	brick and concrete	
Type of heating system	Fan coils	supplied by central heating based on oil boilers
Heating control / regulation	Central with local on-off control	
Domestic water heating	supplied by central heating unit	
Type of cooling system	Fan coils	electricity based

Table 14: Level 1 and 2 calculations on Greek cs N° 1

Capital Costs (€)	existing conditions (owner data 2007 – 2008)	LCC scenario 1 external wall insulation level 1 LCC-DATA database	LCC scenario 2 external shading system level 1 LCC-DATA database	level 2 LCProfit
Project costs	n. a.	n. a.	n. a.	n. a.
Running Costs (excl. energy)	[UNIT: €/a]	[UNIT: €/a]	[UNIT: €/a]	[UNIT: €/a]
Administration	2,519	2,519	2,519	3,160
Operating	3,500	3,500	4,500	40,000
Maintenance	3,395	3,395	4,800	9,288
Development (*)	1,700	40,736	29,558	
Consumption	3,864	3,864	3,864	2,573
water & drainage	1,960	1,960	1,960	1,473
waste handling	1,904	1,904	1,904	1,100
Cleaning	13,713	13,713	14,500	15,886
Service	1,892	1,892	1,892	n. a.
Energy Costs	[UNIT: €/a]	[UNIT: €/a]	[UNIT: €/a]	[UNIT: €/a]
Total energy demand	17,672	16,184	14,871	31,465
Heating	6,467	4,979	6,467	
Cooling	incl. in electricity			
Electricity	11,205	11,205	8,404	

Development (*): In the development costs, at the current situation the amount corresponds to fan coil replacement. In scenario 1 it corresponds to external wall insulation (740.7m^2 x 55€/m^2 = 40,736 € total investment) and in Scenario 2 it corresponds to external shading upgrade (197m^2 x 150€/m^2 = 29,558 € total investment).

From the case study above is apparent the decrease of energy costs after the energy efficiency interventions, with a difference of about € 2,500-3,000 in the energy cost category (decrease for heating and cooling). In addition to that, development costs increase after the proposed intervention – external wall insulation and external shading (this cost item could have been included in the capital cost instead of development cost). Increase on maintenance and cleaning costs appears in case of external shading placement, as respective additional costs arise. Service and administration do not change with the proposed scenarios.

Regarding the comparison between level 1 and level 2 calculations, the following remarks could be noted:

- Administration costs are relatively similar and any difference is due to accuracy of insurance and administration costs (mainly on administration costs).
- Operation costs differ significantly and this is because on level 2 calculation, two full time persons (high yearly salaries) are allocated for maintenance; while in real operation, part time work is affiliated with this task.
- Maintenance costs are almost doubled and this is due to the fact that level 2 calculation set standardised maintenance periods with high standard operation, while often in operation maintenance is underestimated (and especially in this case study).
- Development costs are not considered as no alternatives are tested.
- Consumption costs are relatively close and any differences are caused on fuel prices and actual consumption on building operation. However, an expansion of the database, linking to national energy databases when available will increase validity of results.
- Cleaning cost figures are similar and any differences are due to assumptions made to level 2 calculation (on capacity standards. Also, in level 2 any special cleaning is not included as it does in level 1 calculation.

4.3.3 Case Study Building N° 2, CRES bioclimatic office building

Picture 4: CRES Bioclimatic office building - south façade

Case study N°2 is a CRES building constructed in 2002 as a demonstration project for bioclimatic design principles and RES integration. It was funded by the "General Secretariat of Research and Technology", Ministry of Development and it accommodates office areas, a library and a small meeting room. Passive and hybrid systems (large south openings, sun space on south façade, solar air collector panels integrated on the south façade, atrium, transparent insulation, external shading systems), as well as active and RES technologies (geothermal heat pump, PVs, solar thermal collectors) have been integrated in the building construction and operation. This building is located close to Case Study N°1 described above. It is a concrete structure with brick walls, double glazed windows and one main staircase for vertical circulation purposes.

This case study has special interest in terms of investment and operation costs, having all these energy technologies with high energy design standard.

The energy technologies and systems installed in the building cost, in 1999 prices, account for 11% (€ 39,780) of the total cost of the building. Based on the first measurements in the building and in the calculated energy saving (53,166 kWh/year) compared to a conventional structure, there is a simple payback period of 14.5 years. The payback might have been much smaller, but because the building was a demonstration project, systems were installed which increased the cost of energy technologies and therefore the payback period[4].

[4] Ref: Bioclimatic and Low Energy office building, Centre for Renewable Energy Sources, CRES, www.cres.gr

4.3.3.1 Energy calculation results

Energy consumption data is collected from the technical department of CRES.

Table 15: Energy calculations for the Greek cs N° 2

Figures for the year 2007

case study N° 2	Thermal		Electricity		TOTAL PR year	
	kWh/m² a	kWh/a	kWh/m² a	kWh/a	kWh/m²a	kWh/a
Heating			21,2	9,073.6	21,2	9,073.6
Cooling			32,8	14,038.4	32,8	14,038.4
Lighting			14,9	6,377.2	14,9	6,377.2
Electrical Appliances			35.9	15,365.2	35.9	15,365.2
Sum building			**104,8**	**44,855.4**	**104,8**	**44,855.4**

This building is considered as a demonstration case study with energy efficient and RES technologies applications, having low energy consumption. From the above table and based on energy consumption figures, the building could be rated as “B”.

4.3.3.2 LCC calculations

As described in case study N°1, level 1 and level 2 calculations have been carried out in order to assess the potential of the database use.

Some general input data on case study N° 1 are shown in Table 16. The level 1 and 2 calculations are given in Table 17.

Table 16: General input information about Greek cs N° 2

case study N° 2	***General input*****	Comments
Building information		
Name of building	CRES bioclimatic building	
Location/Country	Athens, Greece	
Type of building	Office building	Existing building
Construction characteristics		
Gross area [m^2]	529	
Heated floor area [m^2]	428	
Non heated floor area [m^2]	101	not parking areas
Performance level	medium	
Maintenance level	medium	
Operation and main installations		
Building management System	occupancy linking control	
Main building material	concrete structure with brick walls	
Type of heating system	fan coils	
Heating control / regulation	combined system	central control with local adjustments
Domestic water heating	Solar collector	
Type of cooling system	air condition (fan coils)	

Table 17: LCC calculation results for Greek cs N°2

Capital Costs (€)	level 1 LCC-DATA database	level 2 LCProfit
Project costs	429,623	n. a.
other	37,843	
energy technologies (geothermal, PVs, solar thermal)	39,780	
conventional construction	352,000	
Running Costs (excl. energy)	[UNIT: €/a]	[UNIT: €/a]
Administration	7,248	4,068
insurance	1,748	1,500
administration & management	5,500	2,568
Operation	1,900	15,558
Maintenance	5,329	3,529
Development (*)	-	-
Consumption	3,324	1,545
water & drainage	2,884	762
waste handling	440	783
Cleaning	5,135	7,098
Service (security)	942	n. a.
Energy Costs	[UNIT: €/a]	[UNIT: €/a]
Total energy demand	14,871	31,465
Heating	6,467	
cooling	included in electricity	
Electricity	8,404	

Significant differences in the cost figures of level 1 and level 2 approach appear mainly in "operation", "cleaning" and "water and drainage". More specifically:

- Administration costs are higher than predicted from level 2 approach, due to the increased management needs of the building technologies (BMS, monitoring works, etc).
- Operation costs differ similarly as in case study N°1, due to the assumed and actual operational hours of the technical relevant staff.
- Maintenance costs are higher in the actual than the predicted figure, as it is difficult to analyse in detail the maintenance of all RES and ES integrated technologies, therefore actual operation appears with higher maintenance costs (for RES technologies and infrastructure and for passive building elements).
- Development costs are not considered as no alternatives are tested.
- Consumption costs are relatively close; these figures could be more accurate in future expansion of the database in which more buildings and cost data are included.
- Cleaning costs are higher as calculated in level 2 possibly due to higher performance standards, or to overestimated figure at level 1 approach.

4.3.4 Case Study Building N° 3 GSIS[5] - Ministry of Finance and Economics

Picture 5: Main building façade of the Greek cs N°3

This building was constructed in 1965 as a Plastic Piping Factory, and in 1999 it was totally renovated to accommodate the office data-centre of the "General Secretariat for Information Systems" of the Ministry of Finance and Economics. It is a 4-storey building, located in Athens, with around 4,800m^2 per floor.

The main construction material is concrete with a large area of glazed façade, with flat concrete roof. The building accommodates offices and data centre facilities, as well as catering facilities. Lifts also exist in the building for vertical circulation purposes.

For input on the energy and cost calculations, detailed data has been provided by the building owner and manager (Hellenic Public Real Estate Corporation – KED).

[5] GSIS: General Secretariat for Information Systems

4.3.4.1 Energy calculation results

For case study N° 3, no analytical TRNSYS energy simulation has been assessed. Energy profile has been provided by the monitoring data of the building manager (KED) and is presented in the table below.

Table 18: Energy calculations for the Greek cs N° 3

Figures for the year 2008 – ref: KED

case study N° 3	**Thermal**		**Electricity**		**TOTAL PR year**	
	kWh/m^2 a	**kWh/a**	**kWh/m^2 a**	**kWh/a**	**kWh/m²a**	**kWh/a**
Heating (oil)	34,1	817,500			34,1	817,500
Electricity – Cooling & other			166,6	3.998,000	166,6	3.998,000
Sum building	**34,1**	**817,500**	**166,6**	**3.998,000**	**200,7**	**4.815,500**

4.3.4.2 LCC calculations

Below are presented the general description data of GSIS building.

Table 19: General input information about the Greek cs N° 3

case study N° 3	***General input*****	Comments
Building information		
Name of building	General Secretariat for Information Systems	
Location/Country	Athens, Greece	
Type of building	Office data centre	Existing building
Construction characteristics		
Gross area [m^2]	30,000	
Heated floor area [m^2]	24,000	
Non heated floor area [m^2]	6,000	underground parking areas
Performance level	medium	
Maintenance level	high	
Operation and main installations		
Building management System	Time scheduling control	
Main building material	concrete structure with extensive glass facades	
Type of heating system	fan coils	
Heating control / regulation	combined system	central control with local adjustments
Domestic water heating	electric	
Type of cooling system	water pipes	

Table 20: LCC calculations for level 1 and 2 of the Greek cs N°3

Capital Costs (€)	level 1 LCC-DATA database	level 2 LCProfit
Project costs	26,400,000	n. a.
Running Costs (excl. energy)	[UNIT: €/a]	[UNIT: €/a]
Administration	n. a.	63,039
Operating	*included in maintenance*	102,000
Maintenance	621,000	96,308
Development (*)	-	-
Consumption	n. a.	1,545
water & drainage	-	43,197
waste handling	-	45,339
Cleaning	384,000	368,225
Service (security)	240,000	n. a.
Energy Costs	[UNIT: €/a]	[UNIT: €/a]
Total energy demand	496,030	741,483
Heating	56,250	
cooling	*incl. in electricity*	
Electricity	439,780	

From the figures in Table 20, significant differences on operation and maintenance costs appear as well as for energy costs. However, cleaning costs are very similar figures.

Discrepancies on operation and maintenance are possible because the maintenance costs given by the building owner (LCC-DATA database) include emergency interior repairs and significant periodical maintenance of exterior. Compared to other case studies, the maintenance costs are relatively high due to the performance standard of the building and envelope construction.

Regarding energy costs, significant differences might be due to special rate for public sector as well as overestimation in the software tool compared to actual performance.

Waste handling costs are not included in the database; however an estimate is calculated with the software tool.

4.3.5 Conclusions

It is justified that the development and expansion of the LCC-DATA database will significantly increase the potential of its use in the study of LCC analysis. The enrichment of the database with different buildings from private and public sector will provide validity to the cost indicators and increase the potential of its use in daily practice LCC calculations.

The current disadvantage of the database is the limited number of building entries which are mainly due to the time consuming partnership co-operations with potential building owners and users of the database. In addition to that, as the database is in excel format (at this stage) and not in a highly interactive format, this decreases the facility to process and elaborate the cost data entries.

It is a highly promising tool as a potential to facilitate LCC analysis in the building sector, especially for Greece, where the market is not familiar with LCC calculation and approach. Therefore, such a tool will support their work either for benchmarking purposes or for level 1 LCC calculations.

Referring to each cost category, the following can be summarised:

Capital costs: this figure is often missing by the building managers and owners, especially in cases of existing buildings older than 5 years. However, compared to other costs in a building's lifetime (operation, maintenance, etc), it is significantly lower, so no priority is given. In addition to that, average construction costs per m^2 and per building use are often available at national statistical level, so such cost indicators could be estimated and used as input in the level 1 LCC analysis.

Administration costs: the database need to be enriched with more building cost entreis in order to obtain accurate estimates, especially about administration and management services. However, for case study 1 and 2 both level calculations have similar results.

Operation costs: operation is often included in maintenance costs by the building managers and owners. Differences that appear in level 1 & 2 approaches are due to the fact that actual and predicted work run by own employees is often over- or underestimated. In cases that operation and inspection is done by external subcontracts, figures are more clear and accurate in annual basis.

Maintenance costs: maintenance is often disregarded and special maintenance works - replacement or emergency repairs- increase this cost category. Systematic maintenance would decrease the special maintenance and avoid any material or construction failures. The experience of this study and the data collection work (WP 3) shows that potential market actors are highly interested in maintenance costs and especially to the ones related to envelope components and systems, as well as energy and RES technologies.

Development costs: the development costs are sometimes included in the capital or maintenance costs. These figures are of high interest examining the building in its lifetime, especially for new types of element construction and also for existing buildings if their use will be changed, they are to be expanded, totally refurbished or similar.

Consumption costs: consumption costs differ from level 1 and level 2 approach as initially expected.

Energy: With the implementation of the EPBD at national level and the energy performance certificates, energy data for a vast variety and sample of buildings will be available, so estimates on actual energy consumption figures will increase their accuracy. In such cases, differences in post occupancy evaluation figures compared to simulated figures will be eliminated, transferring experience and actual performance indicators into initial performance predictions.

Water: it was recommended to split drinking water to grey water as it impedes the comparison of level 1 and level 2 calculation results. In addition to that, enrichment on the database entries, will provide justified cost figures for different building types.

Waste: this cost indicator is important in order to raise awareness on cost management purposes during operation.

Cleaning costs: these costs have similar results from Level 1 and Level 2 calculation approaches; often level 2 appear with higher cost figures. This could be justified by the difference in cleaning standards calculated and actually performed.

Service costs: not enough data is collected for service costs, this area need to be explored in the future cost data collection, in order to understand its share on the total operational cost of the building

Out of the case studies and in combination with feedback from building owners and facility managers (WP 3 and national workshops feedback), it appears that at this stage of database development it is difficult to obtain accurate cost indicators, however early stage assumptions could be made. A combination of level 1 and 2 calculation methods is proposed in order to have an analysis which is accurate enough and not highly time consuming. The potential of efficient use of the database is high and continuous entry processes beyond the project duration will ensure that this tool will be valuable for the building industry.

4.4 Case studies Slovenia, BCEI ZRMK

4.4.1 Aims and objectives

The LCC calculations in this report are aiming to demonstrate the economic justification of energy efficient building concepts. The real life situation for the use of LCC in building design and renovation were selected: new building design at the stage of architectural competition (level 1), initial design of apartment building (level 1), feasibility study of an alterative energy system (level 2) and energy renovation of public social housing (level 2).

For level 1 calculations the data collected in this project (WP 3) were used, where two building categories were focused on: residential apartment buildings and public educational buildings – schools. For energy costs the LCC database was expanded with existing data for benchmarking in municipalities, collected in the year 2000.

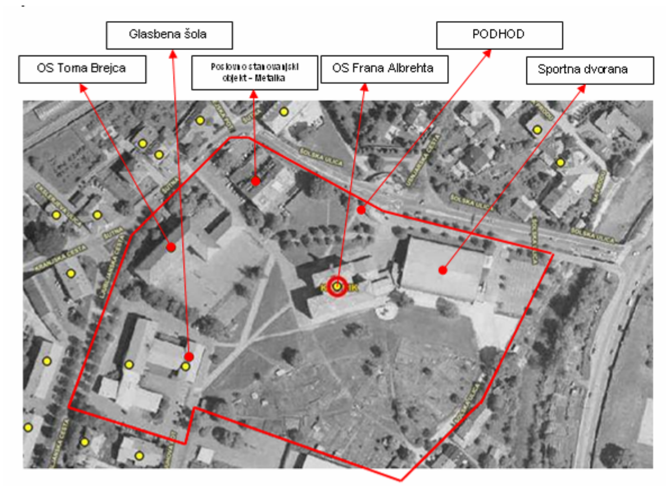
For the level 2 calculations more detailed cost calculation was used based on

- Regulation on maintenance standards for residential buildings and apartments, ("Pravilnik o standardih vzdrževanja stanovanjskih stavb in stanovanj, Uradni list RS 20/2004 z dne 4. 3. 2004").
- "CENING": database of costs for construction works – per elements and phases, used for calculation of construction work costs.

4.4.2 Case Study Building N° 1, architectural competition in Kamnik

The new project "OŠ Frana Albrehta" requires for a capacity of 672 pupils with 4,867 m^2 and for "OŠ Toma Brejca" a capacity of 524 pupils with 4,749 m^2 of net floor area is required.

Picture 6: Site plan Kamnik school



Picture 7: Kamnik school area - from architectural competition TOR

Picture 8: The awarded architectural solution for Kamnik schools

The architectural competition was published in October 2007 and was evaluated in autumn 2008. The design conditions contained the requirements for energy efficiency and possible use of renewables, as well as a development of design in compliance with the new EPBD regulation, ambitious RES and RUE targets for public sector (Energy Efficiency Action Plan, EEAP) and potential use of cohesion funds.

4.4.2.1 Energy calculations

Energy calculations at the level of architectural competition only allow for very rough calculations of energy consumption according to the simplified method from "PTZURES 2008" (EPBD regulation). At this stage only the architectural solution is defined, while the building physics and the energy/installation systems have not yet been developed. As the energy efficiency targets were defined, these were used as a starting point for the energy calculation. The energy demand for heating of very low energy building was 35 kWh/m^{2}a (minimum requirement in regulation for such building is 50 kWh/m^{2}a), electricity energy consumption was assumed based on the average use of electricity in schools, i.e. 33 kWh/m^{2}a. The primary energy consumption was limited to 210 kWh/m^{2}a. A PV power plant was considered, the heat source is district heating.

Conversion factor to calculate primary energy demand for district heating is 1.58 and 2.15 for electricity.

Table 21: Energy calculation results of the Slovenian cs N° 1

	case study N° 1 ***Kamnik architectural competition***
Energy demand	
heating [kWh/m²a]	35
electricity total [kWh/m²a]	33
thereof cooling [kWh/m²a]	*12*
primary energy demand [kWh/m²a]	126
CO_2 emissions	
CO_2 emissions [kg/m²a]	55

4.4.2.2 LCC calculation

Level 1 LCC calculation was used, based on the data collected for schools (large school buildings). Since at this stage the LCC database has got only a limited number of entries, the energy cost information was upgraded with roughly calculated values (energy calculation) and cross-checked with energy indicators from the energy benchmarking database ("SAVE Benchmarking for municipalities", 2000). Investment costs were assumed according to the national database (www.peg-online.net).

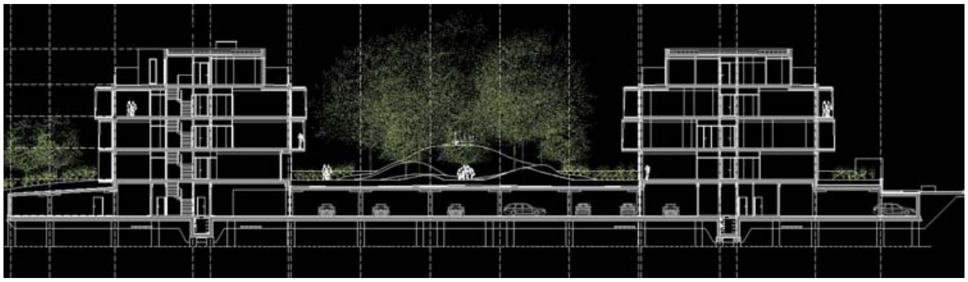
Table 22: LCC calculations of the Slovenian cs N° 1

Capital Costs (€)	level 1 scenario 1: average energy standard	level 1 scenario 2: very low-energy standard
Project costs	8,500,000.00	9,350,000.00
Running Costs (excl. energy)	[UNIT: €/a]	[UNIT: €/a]
Administration	2,695.48	2,695.48
Operating	7,025.50	7,025.50
Maintenance	36,305.90	36,305.90
Development (*)	-	-
Consumption	7,199.63	7,199.63
water & drainage	5,827.67	5,827.67
waste handling	1,371.96	1,371.96
Cleaning	9,453.45	9,453.45
Service (security)	14,042.79	14,042.79
Energy Costs	[UNIT: €/a]	[UNIT: €/a]
Total energy demand	21,946.56	8,848.01
Heating	12,752.59	4,251.00
cooling	included in electricity	
Electricity	9,193.98	4,597.01

4.4.3 Case Study Building N° 2, apartment building near Ljubljana

Picture 9: Architectural visualisation of case study N° 2

source Projekta d.o.o.



Picture 10: Aerial visualisation of case study N° 2

source Projekta d.o.o.

The residential building is composed of 2 wings, each one with 4 storeys and penthouse flats on the top. In the underground level is arranged a common garage and a wellness centre with a swimming pool. 138 flats are planned, with 11,500 m^2 net floor area. The building will be located in the green area of Ljubljana suburbs.

The investor has defined ambitious targets for this apartment building regarding high quality of life in the building, comfortable floor areas of flats, recreating facilities, swimming pool, sauna, a lot of green areas in the surroundings, an atrium with medium sized trees, high level safety and security standards, independent control of thermal comfort parameters in each flat and above all low energy building standards, with use of renewables and as well as with focus on optimization of investment and running costs.

4.4.3.1 Energy calculation

Building structure and envelope:
Concrete load bearing structure is planned, i.e. concrete load bearing walls horizontally connected with concrete plates. The outer envelope is also envisaged to be made of concrete with external thermal insulation. The optimisation of the thickness was subject to consultation process and resulted in 20 cm of expanded polystyrene external insulation on the walls (u-value wall = 0.172 W/m^2K) and 26 cm on the roofs (u-value roof = 0.176 W/m^2K, u-value floor = 0.176 W/m^2K). The aim of the investor is to obtain high ranking in energy performance certificate and to reduce the energy costs. Optimisation of the thermal envelope, openings, glazing; optimization of final energy and costs, demonstrated relatively high investment in triple glazing, therefore double glazing with very well thermally insulated window frames were selected (u-value windows = 1.35 W/m^2K). Average thermal transmission of the whole envelope is u-value medium = 0.047 W/m^2K.

HVAC installation:
Several scenarios were investigated in the consultation process:
(0) gas condensing boilers, split AC systems, floor heating, natural ventilation;
(1) heat pumps geothermal (72[6]) – central preparation of heat and cold, distribution of heat by water media, distribution of cold by air in the ventilation system, mechanical ventilation with heat recovery, recovered heat is used for space heating / cooling;
(1a) – accepted - reduced number of geothermal probes (40);
(2) gas boiler and heat recovery in ventilation;
(3) additional heat recovery of heat from sewage.

Table 23: Energy indicators of the Slovenian cs N°2

Related to the entire building complex per useful m² of flat area

	case 0	case 1	case 2	case 3
Energy (final / delivered) kWh	2,057,000	1,056,000	689,000	1,821,000
Heating (gas)	1,880,000	768,000	485,000	564,000
Electr & Cooling	177,000	288,000	204,000	1,257,000
Primary energy kWh	2,260,550	1,387,200	923,600	3,266,550
CO_2 emissions kg CO2	507,410	321,600	214,820	790,290
Primary energy kWh/m2	197	121	80	284
CO_2 emissions kg CO2 /m2	44	28	19	69

[6] Number of geothermal probes

4.4.3.2 LCC calculation

Four LCC cases were calculated for this building. For LCC in early design stage the level 1 LCC is appropriate. The data was taken from the LCC-DATA database (under development in this project). Due to the currently small sample of residential buildings in the database at this stage, the costs used for LCC may rather illustrate the method than be fully representative. But since the data collection in residential buildings is ongoing, the reliability of LCC level 1 data is growing.

The energy data are calculated more detailed (level 2) for the above defined scenarios (0-3). Such approach reflects frequent situation in practice, where more important costs are calculated / simulated more in detail. Modified case 1 was selected, with support of LCC calculation.

Chart 3: Energy costs in relation to used energy
Source: TST, d.o.o.. Coolregion

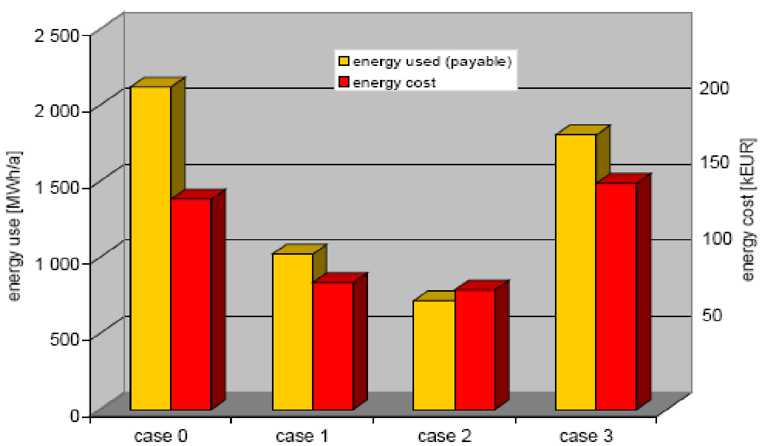


Chart 4: Energy costs in relation to investment costs
Source: TST, d.o.o.. Coolregion

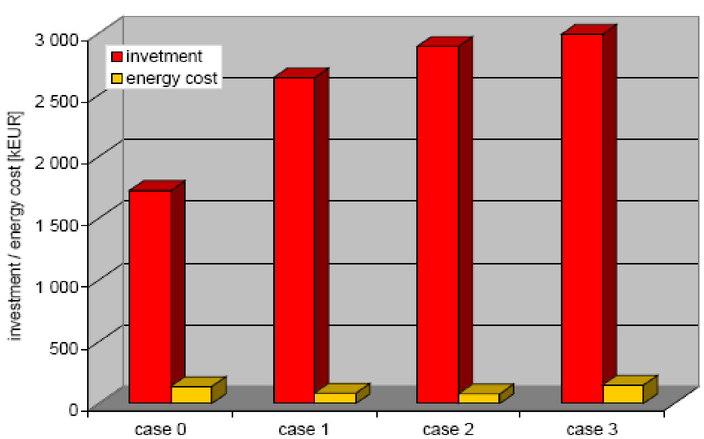


Table 24: LCC calculation results of Slovenian cs N° 2

		Large apartment building near Ljubljana				
Costs		case 0	case 1	case 2	case3	**level**
Currency		EUR	EUR	EUR	EUR	
Main category	**sub category**					
Capital costs		**17,100,000**	**18,000,000**	**18,150,000**	**18,350,000**	**2**
Administration costs		**14,030,00**	**14,030**	**14,030**	**14.030**	
	Insurance	14,030,00	14,030	14,030	14,030	**1**
Operating costs		**2,300**	**2,300**	**2,300**	**2,300**	
	Operation and inspection external	2,300	2,300	2,300	2,300	**1**
Maintenance costs		**246,939.50**	**259,440.00**	**261,523.42**	**264,301.31**	
	Periodic maintenance of internal	9,430	9,430	9,430	9,430	**1**
	Replacement of interior	237,509.50	250,010.00	252,093.42	254,871.31	**1**
Development costs		**0.00**	**0.00**	**0.00**	**0.00**	
Consumption costs		**248,020**	**199,203**	**185,980**	**242,346**	
	Energy	**191,083.50**	**142,266.50**	**129,043.50**	**185,409.50**	
	Heating	108,822	38,065	8,606	52,916	**2**
	Electr & Cooling	24,060	46,000	62,236	74,292	**2**
	Households' Electricity	58,201.50	58,201.50	58,201.50	58,201.50	**2**
	Water and drainage	50,036.50	50,036.50	50,036.50	50,036.50	**1**
	Waste Handling	6,900	6,900	6,900	6,900	**1**
Cleaning costs		**9,200**	**9,200**	**9,200**	**9,200**	**1**
Service costs		**0.00**	**0.00**	**0.00**	**0.00**	

4.4.4 Case Study Building N° 3, social housing Steletova

Picture 11: Steletova – before renovation
Source JSS MOL

Picture 12: Steletova –after renovation
Source JSS MOL

The Housing Fund JSS MOL – public fund of Municipality Ljubljana (280,000 inhabitants) –is owner of 3,200 flats. In general the flats are in buildings with mixed ownership, where problems around effective decision making are a key barrier for energy renovation. The apartment block Steletova is 100% owned by JSS MOL. The tenants are low income tenants, where paying the operational costs may become a problem and if not paid, this would cause an additional burden for Ljubljana Housing Fund. The fund has opted for energy efficient renovation of existing buildings and selected Steletova building as a case study. Usually studies were done during the design stage, but LCC was not part of it. The case study N° 3 aims to demonstrate post-evaluation of energy efficiency renovation project (completed in summer 2007), using also LCC analysis.

The Steletova building nr. 8 has got 3,800 m^2 of useful net floor area and 60 flats.

- Status before the renovation:
  - wall 17 cm concrete + 5 cm thermal insulation (TI)
  - ceiling 8 cm TI
  - windows double glazed, u-value =2,7 W/m^2K
  - QNH[7] = 75-85 kWh/m^2a
  - district heating for space heating
- Planning passive house level renovation:
  - additional thermal insulation (15 cm, roof 22 cm)
  - windows double glazed PVC u-value =1,5 W/m^2K
  - adjustment of heating system
  - mechanical ventilation in main rooms, 75% heat recovery; (old ventilation ducts still in bathrooms and kitchen)
  - external shading
  - partial renovation of heating system
  - target QNH < 15 kWh/m^2a
  - simplified calculation of energy demand; no scenarios, investment costs estimated, lowest prize tender for execution of works selected

4.4.4.1 Energy calculations

Energy calculations were done using PHPP simulation package, according to the boundary conditions in the national regulation. The following cases were evaluated and compared with measurements of before / after case.

SCENARIOS:

-VAR1: existing situation + no measures taken (theoretical)

-VAR2: existing situation; regular maintenance (replacement of windows and facade when necessary due to the lifetime of elements, but no thermal improvement)

- VAR2a: as VAR2 but with actual energy consumption data (“before“ in 2006/2007)

-VAR3: VAR2 + mechanical ventilation with heat recovery

-VAR4: renovation (low-e windows and TI for walls), natural ventilation

-VAR5: renovation (low-e windows and TI for walls) + mech. ventilation (implemented)

-VAR5a: as VAR5 but with actual energy consumption data depending on users' behaviour (“after“ in 2008/2009)

-VAR6: renovation: TI of walls + windows replaced in 10 years

[7] QNH = Q needed heat, while Q stands for the heating energy demand

Table 25: The energy calculation results of the Slovenian cs N°3

Q[8] (kWh)	
VAR 1	332,361
VAR 2	332,361
VAR 2a*	244,990
VAR 3	266,547
VAR 4	154,663
VAR 5	85,558
VAR 5a**	181,150
VAR 6	197,442

*measured ”before”

** measured ”after”

The simulations were performed with the PHPP, respectively measurements were used, as shown in the table below.

Table 26: The specific energy demand of Slovenian cs N° 3

Energy demand for heating per m^2

	Calculation PHPP	**Measurements**
PHPP before renovation	108 kWh/m^{2}a	
PHPP after renovation with ventilation & heat recovery	27 kWh/m^{2}a	
PHPP after renovation, inadequate user habits – open windows simulated	36 kWh/m^{2}a	
“before” – measured in 2006/2007		75 kWh/m^{2}a
“after” – measured in 2008/2009		55 kWh/m^{2}a

[8] Q stands for the heat energy demand of the building.

Chart 5: PHPP energy calculation of Steletova before renovation

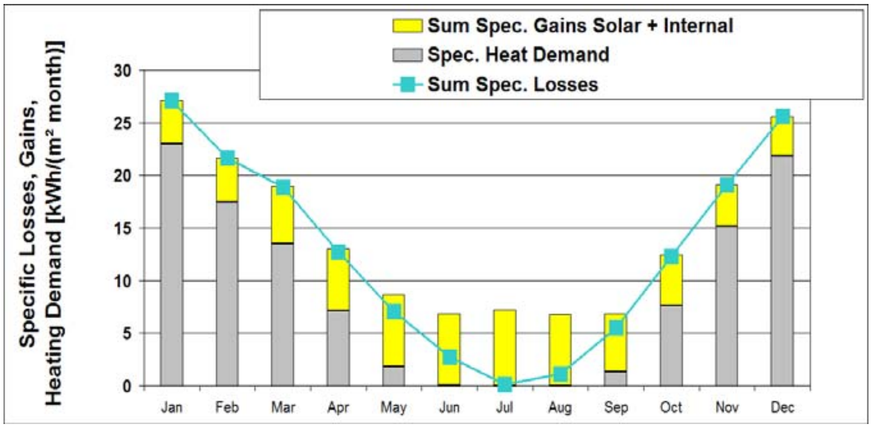


Chart 6: PHPP energy calculation of Steletova after renovation a)

a): ventilation and heat recovery

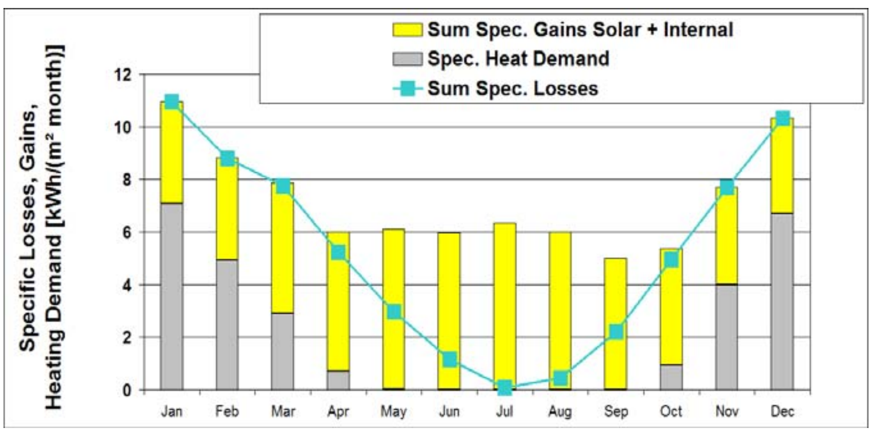
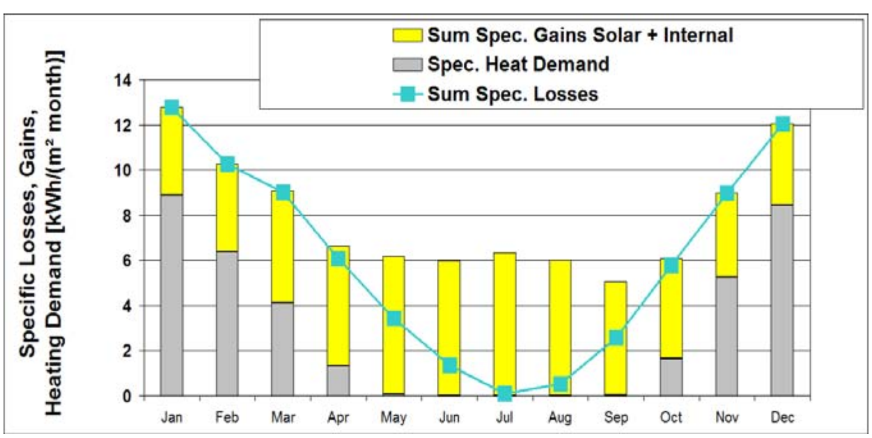


Chart 7: PHPP energy calculation of Steletova after renovation b)

b): inadequate user habits, open windows



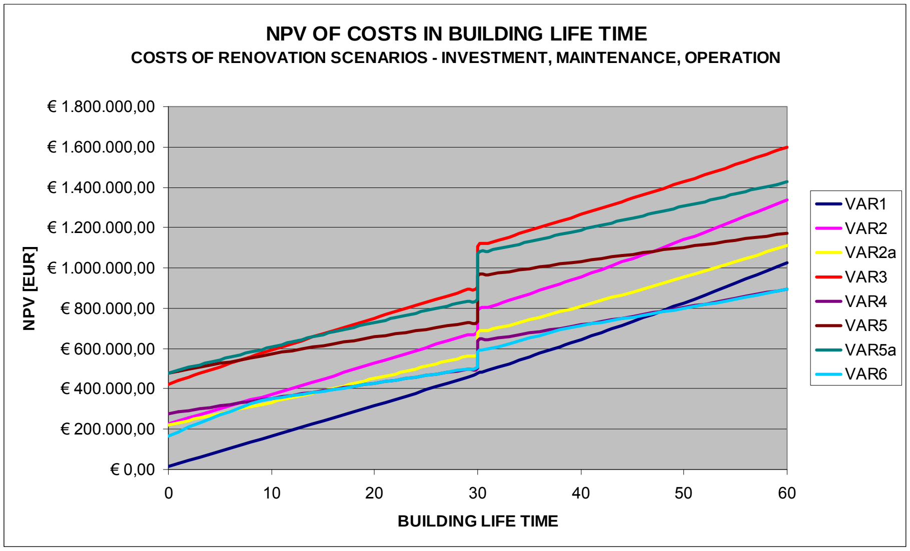
4.4.4.2 LCC calculations

The level 2 LCC calculations were done for several scenarios of building energy renovation:

SCENARIOS:

-VAR1:	existing situation + no measures taken (theoretical)
-VAR2:	existing situation; regular maintenance (replacement of windows and facade when necessary due to the lifetime of elements, but no thermal improvement)
- VAR2a:	as VAR2 but with actual energy consumption data (“before“ in 2006/2007)
-VAR3:	VAR2 + mechanical ventilation with heat recovery
-VAR4:	renovation (low-e windows and TI for walls), natural ventilation
-VAR5:	renovation (low-e windows and TI for walls) + mech. ventilation (implemented)
-VAR5a:	as VAR5 but with actual energy consumption data depending on users' behaviour (“after“ in 2008/2009)
-VAR6:	renovation: TI of walls + windows replaced in 10 years

Chart 8: NPV of renovation scenarios in dependence of building lifetime, Steletova



NPV (net present value) of various scenarios (defined by scenario of building renovation and users' behaviour patterns) is demonstrated in the figure above in relation to the building lifetime.

For the lifetime of 30 years the lowest NPV is obtained in scenario VAR4 and VAR6 (envelope insulation, windows, but no mechanical ventilation with heat recovery). For the lifetime of 60 years the most economically viable scenarios do not differ, but it can be also seen, that the investment in VAR 4 and/or VAR 6 pays out with the energy savings in comparison with the initial scenario VAR1 in 48 years (replacement of elements is needed after 30 years). The implemented scenario VAR5, which also offers better thermal comfort (not financially evaluated), has an average NPV value of € 1,172,425. If mechanical ventilation with heat recovery is not properly used (VAR5a) than the NPV of renovation measures is increased to € 1,427,608. The impact of different scenarios on investment vs. operational and maintenance costs is demonstrated in the last two diagrams; operational costs paid by the tenants are reduced to 30% in VAR5.

Table 27: NPV of renovation scenarios of Slovenian cs N°3

Depending on the building lifetime (30 years, 60 years)

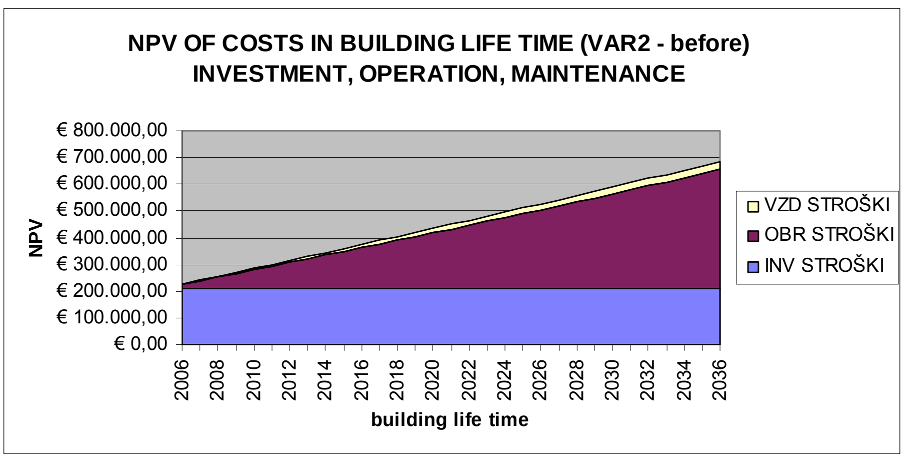
Building life time	VAR1	VAR2	VAR2a	VAR3	VAR4	VAR5	VAR5a	VAR6
NPV30 in €	475,485	787,762	676,847	1,106,106	636,299	960,269	1,071,713	582,766
NPV60 in €	1,024,328	1,336,605	1,110,974	1,599,800	896,762	1,172,425	1,427,608	892,864

Table 28: NPV per year and yearly money savings of the Slovenian cs N°3

Based on LCC analysis of renovation scenarios in dependence of the building lifetime (30 years, 60 years)

Building Life time	**VAR1**	**VAR2**	**VAR2a**	**VAR3**	**VAR4**	**VAR5**	**VAR5a**	**VAR6**
NPV30 €/ m^2a	125.13	207.31	178.12	291.08	167.45	252.70	282.03	153.36
NPV60 €/ m^2a	269.56	351.74	292.36	421.00	235.99	308.53	375.69	234.96
savings NPV30 €/ m^2a	0.00	82,.18	52.99	165.95	42.32	127.57	156.90	28.23
savings NPV60 €/ m^2a	0.00	82.18	22.80	151.44	-33.57	38.97	106.13	-34.60

Chart 9: NPV for VAR2, Steletova



4.4.4.3 Conclusions

Several energy (10) and LCC (22) calculations were done in this WP with the aim of testing the level 1 and level 2 approach to LCC calculation in Slovenian design practice. The quality of level 1 LCC analysis clearly depends on the critical number of entries in the costs database.

The LCC-DATA project generated the interest of Slovenian investors (schools – municipalities, housing funds, building management companies and construction companies) to provide the data and finally co-operate in development of new LCC supported service for the construction sector. Follow-up of this project developed in the frame of Slovenian construction technology platform and managed by ZRMK will enable additional data collection in residential and school sector.

The need for level 1 data has also been identified in practice, since the economic crisis forced the developers to change the attitude and turn towards design for clients, which also includes the evaluation of future MOM costs earlier at the design phase.

LCC level 2 calculation is a building tailored analysis and in principle depends on the detailed data on building elements, life time and maintenance needs/requirements, but often certain data regarding MOM costs (such as cleaning, management, insurance, water) are taken from level 1 LCC calculation, since more reliable calculations are not possible.

4.5 Case studies Austria, Austrian Energy Agency

4.5.1 Aims and objectives

One of the aims of the Austrian Energy Agency is to enhance the amount of new constructed office buildings in low-energy quality (e. g. by using passive-house components) and to support the thermal refurbishment of existing buildings. The total potential carbon savings of the building sector is at minimum 2.3 million tons of CO_2-equivalent[9].

The case study buildings were chosen and analysed concerning the aim of the LCC-DATA project, which is to make the advantage of LCCA for decision makers visible. Therefore the case study buildings used are typical Viennese office buildings: two newly built and one refurbished. The LCC analyses were completed for different scenarios of energy consumption (according to the energy performance certificate).

[9] Emissions above Kyoto-aims of the category buildings heating and small consumption; "Klimaschutzbericht 2008", Umweltbundesamt, Vienna 2008

4.5.2 Case Study Building N° 1, TECHbase

Picture 13: TECHbase Vienna

Photo credit: WWFF

The first case study is a typical Viennese office building with an overall rentable floor area of 12,500m², of which 7,500 m² is used as office area.

It was constructed in 2005, as a combined construction of concrete walls and ceilings with outside insulation, light construction insight and double glazed windows. It is located in a dense urban environment and is not attached to other buildings.

The averaged u-values are: external shell 0.44 W/m²K, windows 1.3 W/m²K, the roof 0.24 W/m²K and the basement 0.40 W/m²K.

There is a district heating system providing heat for the radiators in the offices. The ventilation system is a mechanical balanced system including air-to-air heat recovery. The cooling system is conventional centralised with local fan coils. The lighting is switched on manually.

The calculated energy demand for space heating is 83.9 kWh/m²a, and the demand for electricity consumption is 65.8 kWh/m²a. This is required by the minimum 2005 standard for energy demands according to Viennese building code.

4.5.3 Case Study Building N° 2, BRC

Picture 14: The BRC

Photo credit: WWFF

The second case study building is an office building also constructed in 2005. It is a massive reinforced concrete construction. The rentable floor area is about 5,110m² situated on 7 floors. The building is calculated according to (VAR 1) the legal framework of 2005 and also (VAR 2) for the new regulations, which will come into force in January 2010.

The u-values used are: external shell 2005: 0.50 / 2010: 0.30 W/m²K, the windows averaged u-value is 2005: 1.90 / 2010: 1.2 W/m²K, the roof 2005: 0.25 / 2010: 0.20 W/m²K and the cellar-ceiling 2005: 0.45 / 2010: 0.25 W/m²K

There is a central heating system with radiators in the offices, the source for heating is district heating. There is no ventilation system (natural ventilation). The cooling system is conventional centralised with local fan coils. The lighting is switched on manually.

The calculated energy demand for space heating is 2005:45.8 / 2010: 29.8 kWh/m²a, the demand for electricity consumption is 2005:48.81 / 2010: 51.6 kWh/m²a. The minimum requirements for energy demands according to regulations of 2005 (Viennese building code) respective 2010 (OIB-RL 6[10]) are followed.

[10] Gs, this is the national guideline for energy conservation and thermal protection

4.5.4 Case Study Building N° 3, Mariahilfer Straße

Picture 15: The Mariahilfer Straße

Photo credit: WWFF

The third case study is an existing office building constructed in 1970/71 and refurbished in 2006. The building has seven floors, of which six are used as offices (rentable floor area 3,600m²), on the ground floor there is a shopping-mall. Additionally there are two floors underground, which are used as parking area.

The building is of brickwork construction, with some concrete adjustments made within the refurbishment phase. In addition, the external walls have received additional insulation, the roof has been insulated and the windows have been changed.

The new, averaged u-values are: external shell 0.40 W/m²K, windows 1.33 W/m²K, roof 0.25 W/m²K and the cellar-ceiling 1.90 W/m²K (not refurbished).

There is a central heating system with radiators in the office rooms, the source for heating is natural gas. There is no ventilation system (natural ventilation). The cooling system is conventional centralised with local fan coils. The lighting is switched on manually in the offices and there are movement detectors in the corridors.

The calculated energy demand for space heating after refurbishment is 55.3 kWh/m²a, the demand for electricity consumption is 54.7 kWh/m²a. This is required by the minimum 2006 standard.

4.5.5 Energy calculation results

The outcome of the energy calculations according to the Austrian guidelines presented in chapter 3.1.5.1 are shown in the following table.

Table 29: energy calculation results

	case study 1	***case study 2, (VAR1) 2005***	***case study 2, (VAR2) 2010***	***case study 3***
Energy demand				
heating [kWh/m²a]	83.9	45.8	29.8	55.3
electricity total [kWh/m²a]	65.8	48.81	51.6	54.7
thereof cooling [kWh/m²a]	*11.7*	*12.3*	*15.2*	*24.6*
primary energy demand [kWh/m²a]	243.1	175.3	179.9	256.3
CO_2 emissions				
CO_2 emissions [kg/m²a]	139.5	102.43	107.25	132.54

A particularly interesting remark is that, in case study N° 2 the CO_2-emissions in 2010 will be 4.82 kg/m² higher than those in 2005. This increase is the result of higher overall electricity demand, caused by a higher cooling demand due to thermal gains. The coefficient for electricity is higher than the coefficient for heating covered by district heating. The total amount of increased emissions will be about 20,200 kg of CO_2 for this building. This demonstrates the need for efficient building operation systems, renewable resources and the need to install effective shading systems, as shown in this particular case study.

If, for example, the building was constructed as a passive house construction, the total energy demand could be reduced down to 30 kWh/m², which would lead to the reduction of primary energy demand from 205 / 175 / 256 kWh/m²a now to 100 kWh/m²a if the total demand is covered by electricity (UCPTE mix). Compared to the demand values of the realised passive-house office building "ENERGYbase", the potential of the case studies for primary energy saving is 104 / 75 / 150 kWh/m²a. This reduces the CO_2-emissions down to 61.27 kg/m²a which is nearly half.

Additionally, the electricity demand of the building could be covered by hydro-electricity, through purchasing from a hydro electricity supplier, which means the further reduction of the carbon dioxide down to 0.32 kg/m²a. If the three introduced case studies were not build according to the minimum requirements, but according to passive house requirements and the electricity demand would only be covered by Austrian hydro-electricity, the total emission saving potential would be about 2,440,478 kg every year.

Picture 16: The passive-house ENERGYbase

The south façade is folded: the windows are shaded by PV- and solar-panels

Photo credit: WWFF

4.5.6 LCC calculations

As mentioned before, the Austrian Energy Agency used key-figures for the level 1 analysis, generated by the benchmark-database of IBI. The needed input to generate the key-figures is shown in the following figure:

Table 30: IBI categorisation of buildings

elements	simple	medium	high
construction, floor plan	simple construction, fixed floor plan	simple construction, flexible floor plan	structured construction, flexible floor plan
facade	punched facade, rows of windows, simple materials (e.g. plastering)	rows of windows, curtain-wall facing, medium materials	curtain-wall facing, high materials
basement, electricity	massive basement, single outlets / wall cable conduits	massive basement, wall or floor cable conduits	false floors, cavity floors, cable conduits, in-floor tanks
ceiling, lighting	massive ceiling, suspended ceiling and ceiling lighting	suspended ceiling with high quality lighting	suspended ceiling with indirect lighting
heating and ventilation	conventional heating and natural ventilation	conventional heating and partly mechanical ventilation	innovative heating and mechanical ventilation
other equipment	data networks, access control, smoke-detectors	as before, additionally elevators, emergency power supply	as before, additionally BMS, video-control

After having entered the data into the IBI database for benchmarking the contained building data, the generated benchmarks can be used as key-figures. This was done to calculate the annual costs for the case study buildings.

The following table shows the result for generated key-figures out of the IBI database for office buildings, classified according to the LCC-DATA cost categories.

The key-figures are shown in € per m² (net floor area) and year.

Table 31: The Austrian key-figures

Cost categories	key-figures of the IBI database in € / m² a		
	mean	p25	p75
Capital costs	**not included in the IBI database**		
Administration costs	**4.30**	**2.64**	**5.04**
taxes	1.16	0.16	1.77
administration	2.06	1.65	2.14
insurance	1.08	0.83	1.13
Operating costs	**2.32**	**1.10**	**3.55**
engineering firm	2.32	1.10	3.55
Maintenance costs	**18.03**	**5.89**	**17.81**
inspections	2.82	1.35	3.87
maintenance	15.22	4.54	10.39
Development costs	**not included in the IBI database**		
Consumption costs	**12.53**	**8.29**	**16.41**
heating	6.42	4.91	7.95
cooling	**included in electricity**		
electricity	3.50	1.42	5.24
water consumption	1.19	0.63	1.40
waste handling	1.41	1.33	1.82
Cleaning costs	**6.85**	**3.87**	**11.03**
Service costs	**3.10**	**1.30**	**3.27**
security	1.78	0.64	2.46
others	1.32	0.66	0.81

For the calculations a life time of 80 years for offices and the interest rate figure of 6 % p. a. was used. The results of the level 1 and level 2 analysis for the case studies are shown in the Table 32.

The Real Estate Valuation Law was the basis for the level 2 analysis to be comparable with the market situation, as investors decide according to this factor. The results for the Austrian case studies are shown in Table 33.

Table 32: Results of the Austrian case studies level 1 analyses

Cost categories	case study 1	case study 2. 2005	case study 2. 2010	case study 3
Capital costs	*n.a.*	*n.a.*	*n.a.*	*n.a.*
Administration costs	**€ 37,762.50**	**€ 16,325.75**	**€ 16,325.75**	**€ 6,600.00**
taxes	13,237.50	4,412.75	4,412.75	400.00
administration	16,050.00	7,820.40	7,820.40	4,125.00
insurance	8,475.00	4,092.60	4,092.60	2,075.00
Operating costs	**€ 26,625.00**	**€ 11,867.98**	**€ 8,825.50**	**€ 5,806.25**
engineering firm	26,625.00	8,825.50	8,825.50	5,806.25
Maintenance costs	**€ 106,950.00**	**€ 92,146.93**	**€ 68,524.13**	**€ 14,725.00**
inspections	29,025.00	10,703.33	10,703.33	3,375.00
maintenance	77,925.00	57,820.80	57,820.80	11,350.00
Development costs	*n.a.*	*n.a.*	*n.a.*	*n.a.*
Consumption costs	**€ 110,040.00**	**€ 43,639.20**	**€ 41,857.00**	**€ 29,692.50**
heating	59,625.00	24,396.00	18,658.00	16,050.00
cooling	included in electricity			
electricity	26,265.00	9,351.80	13,307.60	8,755.00
water consumption	10,500.00	4,525.80	4,525.80	1,575.00
waste handling	13,650.00	5,365.60	5,365.60	3,312.50
Cleaning costs	**€ 82,725.00**	**€ 26,042.67**	**€ 26,042.67**	**€ 9,675.00**
Service costs	**€ 24,525.00**	**€ 11,782.53**	**€ 11,782.53**	**€ 3,250.00**
security	18,450.00	6,751.33	6,751.33	1,600.00
others	6,075.00	5,031.20	5,031.20	1,650.00

This table shows the results of the level 1 calculation for the Austrian case study buildings. The key-figures generated from the IBI-database (see Table 31) were multiplied by the floor area [m²] to calculatet the running costs for the cost categories. Finally the yearly costs were determined and the net present values for the case study buildings were calculated. They are as follows:

Case study N° 1: 6,194,887.- €

Case study N° 2 (2005): 2,943,223.- €

Case study N° 2 (2010): 2,863,529.- €

Case study N° 3: 1,056,205.- €

Table 33: Results of the Austrian case studies level 2 analyses

Cost categories	case study 1	case study 2. 2005	case study 2. 2010	case study 3
Capital costs	**€ 17,500,000.00**	**€ 7,154,000.00**	**€ 7,154,000.00**	**€ 2,927,500.00**
Administration costs	**€ 18,000.00**	**€ 9,120.00**	**€ 9,120.00**	**€ 7,800.00**
Operating costs	**€ 36,000.00**	**€ 18,240.00**	**€ 18,240.00**	**€ 15,600.00**
Maintenance costs	**€ 192,500.00**	**€ 78,694.00**	**€ 78,694.00**	**€ 32,202.50**
Development costs	**n. a.**	**n. a.**	**n. a.**	**n. a.**
Consumption costs	**€ 137,045.25**	**€ 46,586.22**	**€ 42,620.35**	**€ 32,359.37**
heating	€ 56,625.75	€ 15,990.83	€ 10,384.97	€ 9,269.87
electricity	€ 75,304.50	€ 28,285.40	€ 29,925.38	€ 20,862.00
water	€ 5,115.00	€ 2,310.00	€ 2,310.00	€ 2,227.50
Cleaning costs	**€ 33,750.00**	**€ 17,100.00**	**€ 17,100.00**	**€ 11,250.00**
Service costs	**€ 17,250.00**	**€ 8,740.00**	**€ 8,740.00**	**€ 5,750.00**

This table shows the results of the level 2 calculation for the Austrian case study buildings. The calculations were made as explained in chapter 1.1.1.1 to calculate the running costs. Finally the yearly costs were determined and the net present values for the case study buildings are as follows:

Case study N° 1: 7,177,839.- €

Case study N° 2 (2005): 2,948,144.- €

Case study N° 2 (2010): 2,882,636.- €

Case study N° 3: 1,733,765.- €

The differences of the NPV of the running costs calculated according to level 1 and 2 are as follows:

Case study N° 1: 982,952.- €

Case study N° 2 (2005): 4,921.- €

Case study N° 2 (2010): 19,107.- €

Case study N° 3: 677,560.- €

4.5.7 Conclusions

The calculation method of the LCC-DATA project enables the user to have an estimate of potential costs for their buildings - in the Austrian part tested for offices. The most practicable way seems to be a combination of level 1 and level 2 analyses, to allow for an easy, more practicable and time-effective method in the calculation of LCC for buildings.

The following paragraphs present a discussion of results taken from level 1 and level 2 analysis. The presentation is organised according to the cost categories defined by the project team (WP 3, data sheet D 9).

Part 1 - the capital costs: The most important figure for developers is the investment for construction. The national database does not include this category, therefore it seems to be the most practicable solution to use the Austria statistical office figure. This figure is regularly updated via the Austrian statistical office. The figure used for the Viennese office buildings is 1,400 €/m² floor area.

Part 2 – the administration costs: For the level 2 calculation a fixed percentage of estimated rental income is used to calculate the administration costs. On the one hand, this creates the additional need for calculating the estimated rental income, on the other hand this is only one figure for all kinds of administration. In the IBI database there is the differentiation into taxes, administration and insurance. This allows the user to choose which categories are important for the building and if the building is to be situated in the mean, p25 or p75 range of available costs (see Table 31).

Part 3 – the operation costs: Within the IBI database this category is covered by engineering firm costs, in the level 2 analysis it is a percentage of estimated rental income.

Part 4 – the maintenance costs: In the IBI database inspections and maintenance costs are collected, whereas in the level 2 analysis it is a percentage of investment costs.

Part 5 – the development costs: Both the IBI database and the national Valuation Law have no option for the calculation of development costs. For the IBI database the answer was that most of the buildings are newer ones and therefore no development is necessary. In the Valuation Law the handling is similar, because in the practical work, development often means refurbishment and is calculated as investment costs for refurbishment.

Part 6 – the consumption costs: In the IBI database it is only possible to get € / m² for heating and electricity. That makes it hard to differentiate between the energy demand of buildings, because “only” the p25 value can be used for low demand and the p75 figure for high demand. In the detailed analysis it is possible to use the demand, calculated with the real energy prices. To show the difference, the case study building 2 was calculated with two different demand scenarios: one scenario according to the minimum Viennese building code requirements in 2005, when the building was constructed and the second scenario according to the new building code requirements coming into force 2010. For the case studies the estimated savings were calculated in the level 2 for the actual energy demand and on the optimised demand (see chapter 4.5.5). The cost saving potential by upgrading the case studies towards passive house quality would be about 97,000 € / 26,000 € / 23,000 € / 18,000 € per year, which equates to 4.58 €/m²a.

Part 7 – the cleaning costs: In the level 1, as well as in the level 2 analyses a fixed figure is used for cleaning costs.

Part 8 – the service costs: Here it is the same as for the cleaning costs.

4.5.7.1 Results

The level 1 analysis is less time-consuming, especially according to the additional work of calculating the estimated rental income for the level 2 analysis.

The comparison of the added yearly costs – either per m² but also per building - reaches nearly the same results as the level 2 analysis: the differences between the total figures are expressed by the following factors (level 1 : level 2):

- case study 1: 14 %
- case study 2, 2005: 1 %
- case study 2, 2010: 1 %
- case study 3: 39 %

The data output of the case study buildings showed the accuracy of the database itself, on the condition that the user fills in the correct values.

The total difference is only little, except for the case of the refurbished building. The big difference for that building results from the operation costs: for the technical equipment the operation costs according to the IBI database is little, but according to level 2 analysis a fixed percentage value of estimated rent income is used – regardless of the technical equipment.

Through increasing the size of the database, the user will be able to calculate further building projects with even greater precision with the key-figures generated by the IBI database.

For one of the case study buildings the calculated cost data were checked and the outcome shows that the estimated costs according to level 1 calculation are only 4 % higher than the real costs (based on the year 2007).

With the calculations done within the project, the Austrian Energy Agency could demonstrate that the level 1 calculation is a practicable way to calculate the estimated costs for office buildings with the use of generated key-figures out of the existing IBI benchmark database. However, regarding the fact that project developers would prefer to compare two different suggestions raised within architectural competitions, it is not possible to compare those in an easy way. The problem is directly linked to the degree of detail of the national database. On the one hand, the building owners are not willing to spent too much time to feed in data regarding their buildings and benchmark them and therefore the description is done in quite a rough manner which means that building categories were performed the preferred choice.

This preferable method was also the case within the project fact sheet (e. g. the categories “performance level” and “maintenance level”). Within the IBI database, the categorisation is on one hand more detailed (see Table 30) and on the other hand, it is not sufficiently detailed to be able to calculate cost saving potentials e. g. for the maintenance of building operation systems or different kinds of facade constructions.

For the very early design stage, when the developer has to decide about the kind of building and the size of the building, the level 1 analysis can be used as an instrument towards decision making. Also, it is possible to make comparisons e. g. the option of using district heating or natural gas as energy source for space heating. However, for this more detailed decision it is more practicable to use the level 2 analysis.

The most applicable way might be the combination of both level 1 and level 2 analyses.

4.6 Case Studies Germany, Berlin Energy Agency

The main target of the Senate Department for Urban Development is a 30 % reduction of CO_2-emissions. To reach this goal a measure plan for the energetic refurbishment of the Senates' properties has been developed. Thus, 7 experienced engineering consultants have been assigned. The Berlin Energy Agency was responsible for the controlling, co-ordination and the quality assurance. These activities have been carried out in close reconcilement with the Senate Department for Urban Development.

An excel database for the properties has been developed by the Berlin Energy Agency. The building information for each building is inserted and evaluated in the database. Additionally, a warrant of apprehension has been developed for the inventory of the buildings, where the data on heating system, cooling system, consumption of electricity, building shell etc. is collected. Furthermore the main content is the information about the energy related measures as a basis for refurbishment decisions.

After the evaluation in the database it is possible to give detailed statements on technical details, investment costs, energy savings, LCC and CO_2-reductions.

The Berlin Senate Department for Urban Development owns and manages about 89 properties, which consist of 329 buildings. These properties have been divided into 7 batches (depending on their administrative department: culture, justice and school) for the development and implementation of energetic measures. The main data on the 7 batches of the properties are to be found in the following table.

Table 34: German properties for the measurements

	properties	buildings	area [m² NGF]	CO_2-emissions [t/a]
justice_1	7	107	136,432	9,780
justice_2	11	65	142,445	19,119
culture_1	15	33	79,165	3,293
culture_2	18	25	153,868	10,878
culture_3	19	25	239,684	9,966
school_1	9	44	92,692	4,682
school_2	10	30	111,266	4,203
total	**89**	**329**	**955,553**	**61,921**

The results and a short characterisation of the 7 batches can be seen in the following chapters.

4.6.1 Case Study N°1, Batch 1, Justice_1

The batch justice_1 consists of a total of 7 properties. About 75 % of the CO_2 emissions are produced by the jail "Tegel". The table below shows the main key data of the batch:

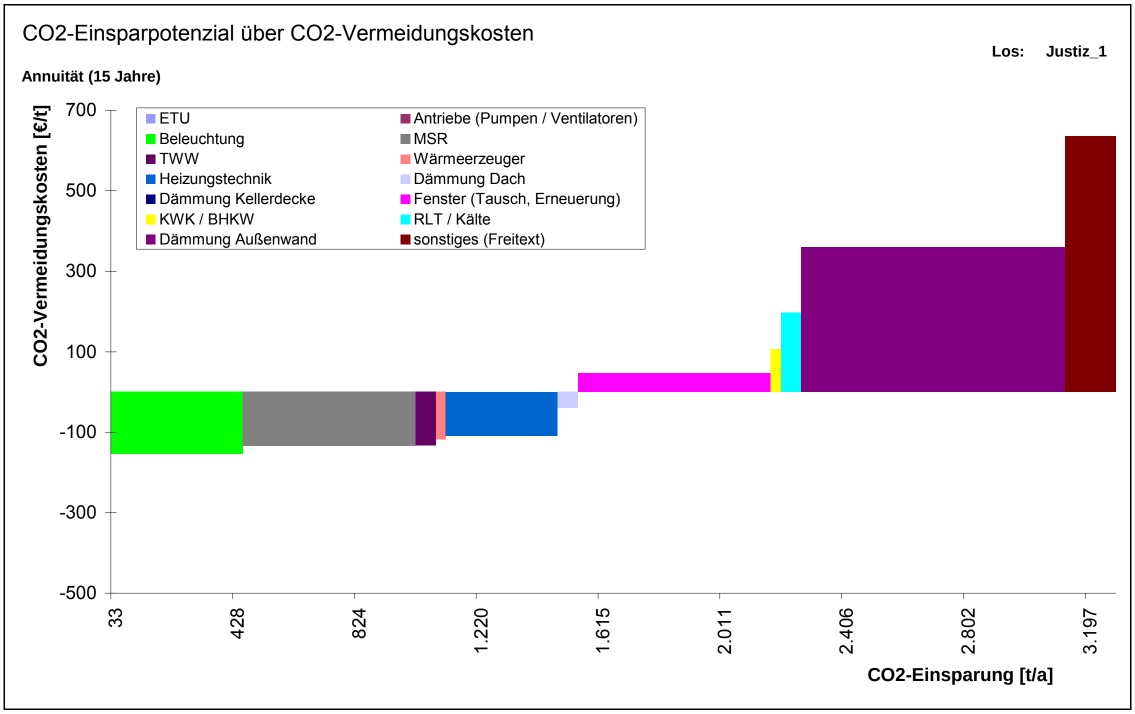
Table 35: Key data of German cs N° 1

Batch		Justice_1
Properties	[number]	7
CO_2-Emissions	[t/a]	9,780
Saving CO_2-emissions	[t/a]	3,280
Saving CO_2-emissions	[%]	34
Percentage on CO_2-savings	[%]	14
Investments	[€]	14,276,670
Energy costs savings	[€/a]	590,516
annual costs [€/a]	[€/a]	272,324
payback period	[a]	24.2
CO_2 abatement costs	[€/t]	83

The investment costs for the batch justice_1 are quite high. The majority of the buildings have been built at the turn of the 18th/19th century or shortly after. Most of the buildings are declared monuments and are in a bad energetic condition. Generally it has to be noted, that all the buildings need comprehensive refurbishment. Therefore measures concerning the whole building shell have been proposed to reduce the CO_2-emissions. By changing the user behaviour and downsizing of the control and heating technique extensive CO_2 reduction can be realised with low financial investments.

In the following table the CO_2 abatement costs for the different measure categories for this batch is given.

Table 36: CO_2-emission saving potential of German cs N°1



4.6.2 Case Study N°2, Batch 3, Culture_1

The batch culture_1 consists of a total of 15 properties. About 17:5 % of the CO2-emissions are produced by one property (Botanic Museum). Table 37 shows the main features of this batch.

Table 37: Key data of German cs N°2

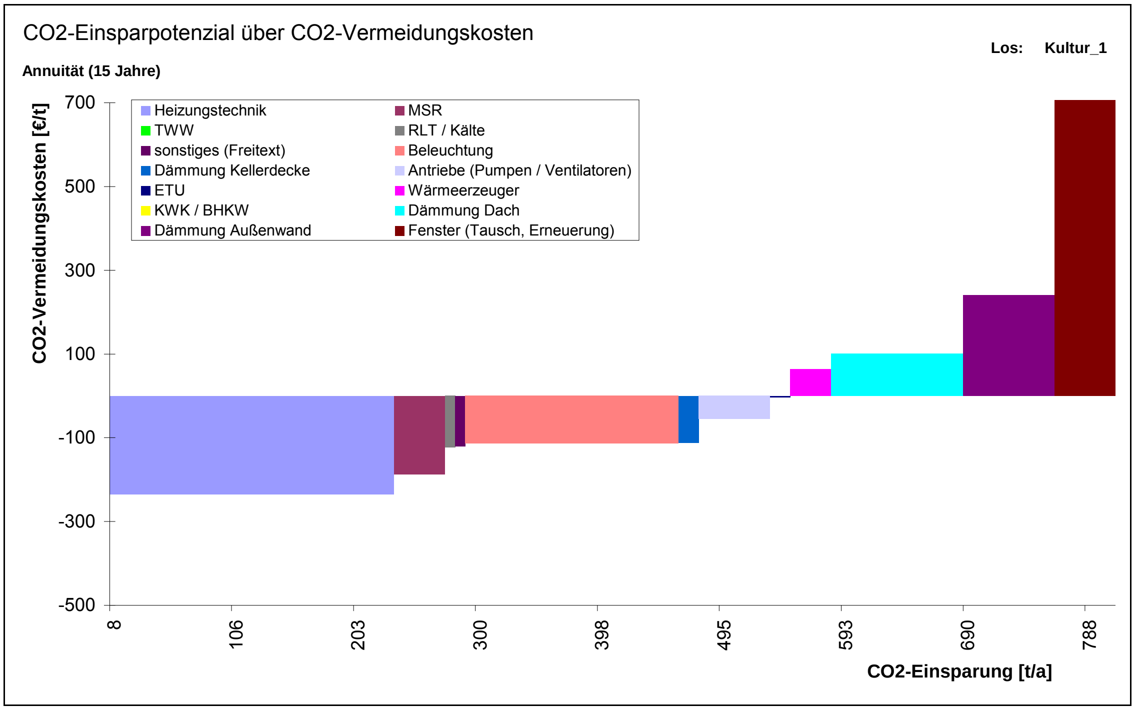
Batch		Culture_1
Properties	[number]	15
CO_2-Emissions	[t/a]	3,293
Saving CO_2-emissions	[t/a]	900
Saving CO_2-emissions	[%]	25
Percentage on CO_2-savings	[%]	3
Investments	[€]	4,753,005
Energy costs savings	[€/a]	188,481
annual costs [€/a]	[€/a]	19,526
payback period	[a]	25.8
CO_2 abatement costs	[€/t]	24

Batch culture 1 mainly consists of properties, which are declared monuments and therefore feature high investment costs for the measures on the building shells. The majority of the properties need refurbishment and the suggested measures concerning the building shell are necessary according to the planners. Batch culture_1 also includes depots and great facilities, whose use intensity is relatively low. The suggested measures concerning the heating and controlling technique are feasible and recommendable. The lighting within the properties should be modernised under energy efficiency aspects as well.

The suggested package of measures can be economically implemented in 8 of the 15 properties.

In the following the CO_2 abatement costs for the different measure categories for this batch is given.

Table 38: CO_2-emission saving potentially of German cs N°2



4.6.3 Case Study N°3, Batch 6, School_1

The batch school_1 consists of a total of 9 properties. About 24,6 % of the CO_2 emissions are produced at the "Oberstufenzentrum Gesundheit". Table 39 shows the main features of this batch.

Table 39: Key data of German cs N°3

Batch		school_1
Properties	[number]	9
CO_2-Emissions	[t/a]	4,682
Saving CO_2-emissions	[t/a]	993
Saving CO_2-emissions	[%]	21
Percentage on CO_2-savings	[%]	4
Investments	[€]	19,271,240
Energy costs savings	[€/a]	213,932
annual costs [€/a]	[€/a]	1,221,816
payback period	[a]	90.1
CO_2 abatement costs	[€/t]	1,231

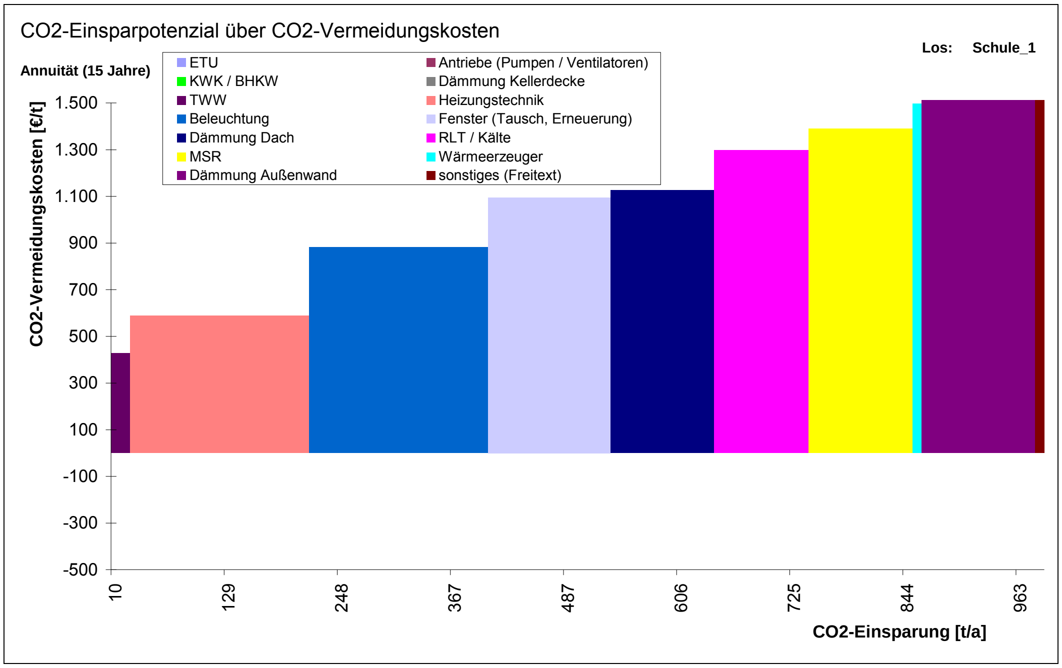
Batch school_1 consists of vocational schools and gym buildings. Various properties have yet been refurbished and therefore have a good heating standard. The suggested measures concerning the building shell will partially lead to minor CO_2 reductions.

As the costs are nearly as high as the costs for a fundamental reconstruction, the CO_2 abatement costs are significantly high. Partially measures concerning the building services engineering have been determined as well, which lead to minor CO_2 reductions and high investments.

Hence it follows, that the suggested reconstruction measures are inefficient while the CO_2 abatement costs range in a positive area.

In the following the CO2 abatement costs for the different measure categories for this batch is given.

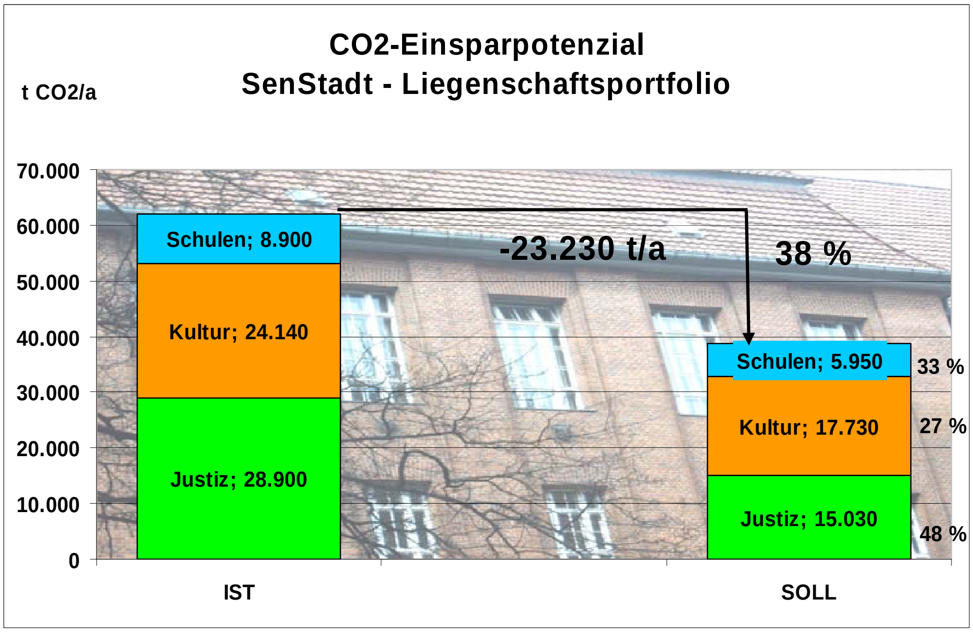
Table 40: CO_2-emission saving potential of Germna cs N° 3



4.6.4 Energy calculation results

In summary, the target of a 30% reduction of the CO_2-emissions in the property of the Senate Department for Urban Development by the implementation of the suggested measures can be achieved.

Chart 10: The CO_2-emissions saving potential of the Berlin Senate buildings



The evaluation of the object-specific energy concepts shows, that CO_2-emissions can be reduced to a total of 38 % in the property of the Senate Department for Urban Development. The highest energy saving potential can be reached in the Department of Justice.

Measures concerning the technical constructions lead to a saving potential of 76 %, heat insulation measures have a potential of 24 %. The use of combined heat and power (CHP) and the change of energy sources in the big properties of the Department of Justice are essential. To fully reach the saving potential a total of 107 million € of investment is necessary.

Chart 11: Rates of CO_2-emission savings of the Batches

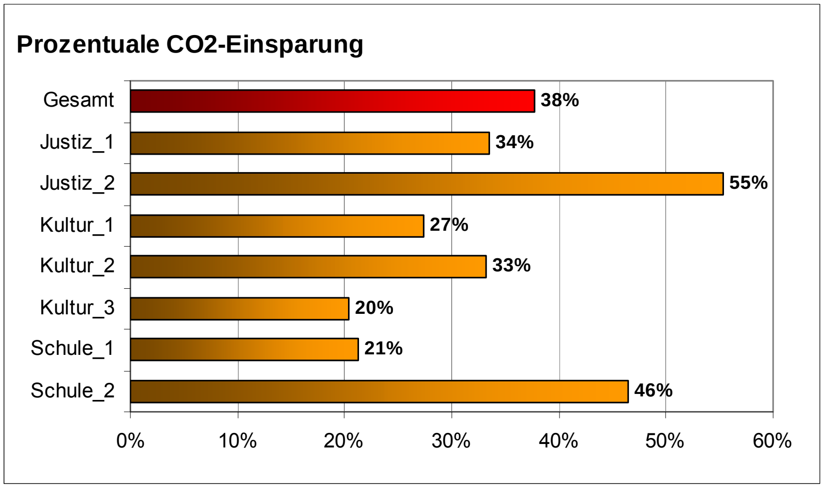
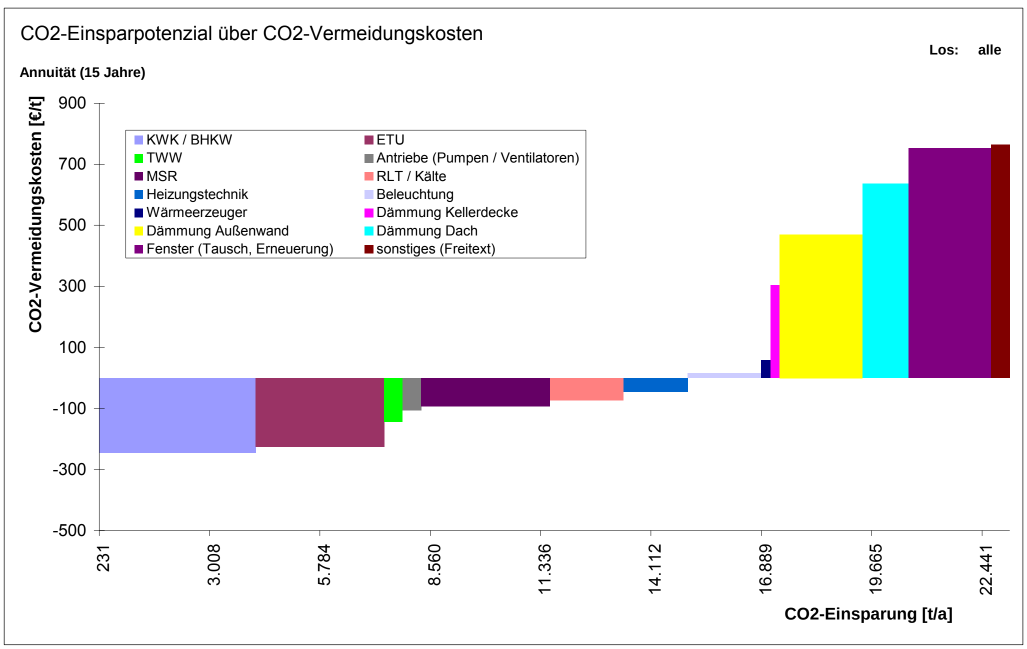


Chart 12 shows the CO_2 saving potential in the several measure categories (CO_2 abatement costs have been taken into consideration) on basis of the energy related LCC analysis. The interdependency between CO_2 savings and abatement costs is the basis for the efficiency feasibility studies.

Chart 12: CO_2-emission saving potential of the single measures



The consideration of the total costs showed that measures in the building shell feature high CO_2 abatement costs in comparison to measures concerning the installation engineering. An investment in the modernisation of the installation engineering or a change of energy sources leads to efficient CO_2 abatement costs.

It has been one target of the project to develop a plan for the implementation of the suggested measures. This plan envisioned the realisation of the whole saving potential within the next 10 years.

Chart 13: realised CO_2 emission saving until 2020

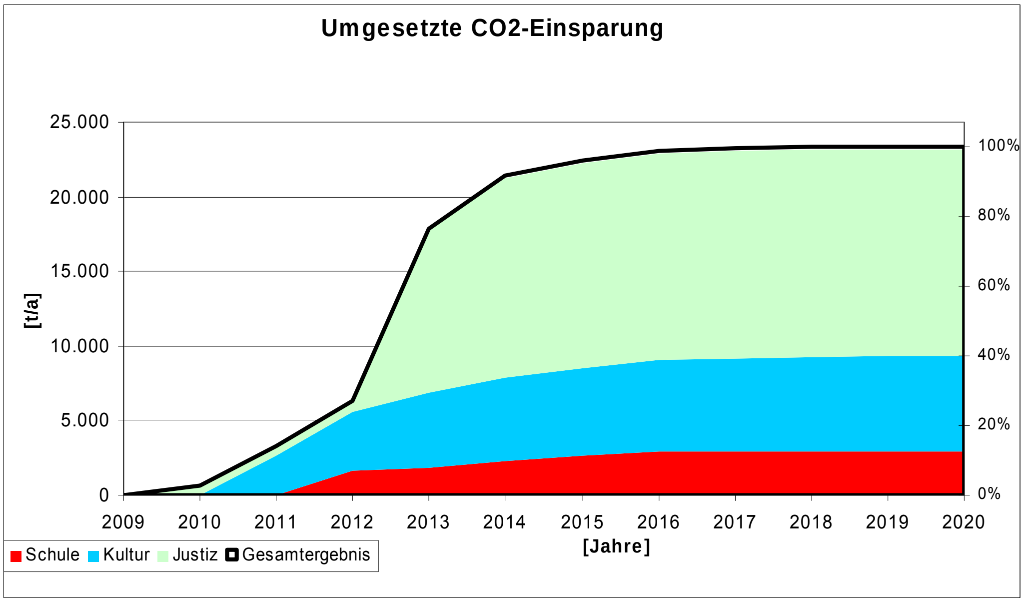
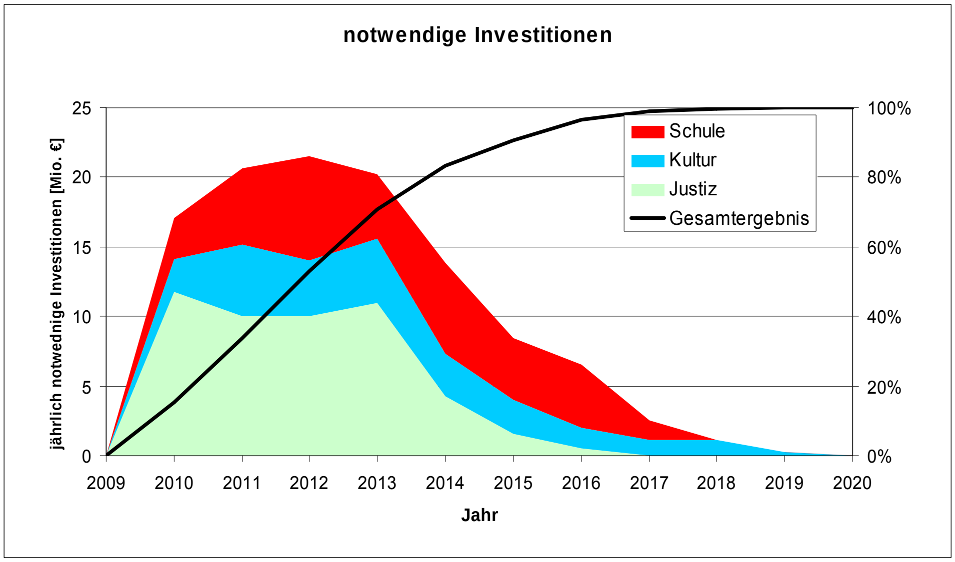


Chart 13 shows the progression of the possible CO_2 savings by the implementation of the measure plan until 2020. The savings are considered to be realised, when the investments for all measures are completed. Therefore more than 70 % of the saving potential can be realised by 2013.

Chart 14: Necessary investment costs for the measures



The chart above shows the investment costs, which are necessary in the next years. While investments of about 20 million € per year are necessary for the first 5 years, investments are already reduced to below 10 million € per year after a third of the implementation timeline.

In summary the planning an implementation should be started for all properties within 10 years, the last measure should be completed after 12 years. The yearly investment volume is estimated with 10 to 20 millions €.

5 General conclusions

For builders, planners and investors the need for level 1 data has been identified in practice, since the economic crisis forced them to change their attitude and turn towards focussing more on the design for their client. This includes the evaluation of future running costs already in the early planning phase.

For this stage, when the developer has to decide about the kind of building and the size of the building, the level 1 analysis can be used as an instrument towards decision making. Also, it is possible to make comparisons e. g. the option of using district heating or natural gas as an energy source for space heating.

However, for this more detailed decision it is more practicable to use the level 2 analysis. Because level 2 LCC calculation is a building tailored analysis and is in principle depending on the detailed data on building elements, life time and maintenance needs/requirements, but often certain data about running costs are taken from level 1 LCC calculation, since more reliable calculations are not possible.

The different results of the calculations according to level 1 and 2 are not that big, as shown in the national case studies. The range within some categories are bigger (e. g. maintenance) and in others the difference is smaller. But in general the level 1 calculation with the LCC-DATA database seems to be useful. For the Austrian database of IBI this is nearly the same: the accuracy ranges from 40 % to 1 %.

But for all further LCC calculations it is important to enlarge the data amount in the databases and therefore get more reliable key-figures for future LCC level 1 calculation.

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8 ANNEX

table of data collection

case study N° X	*input* or result***	Comments
Building information		
Name of building		
Location/Country		
Type of building		main utilisation
Construction characteristics		
Gross area [m^2]		
Heated floor area [m^2]		
Non heated floor area [m^2]		
Performance level		
Maintenance level		
Operation and main installations		
Building management System		
Main building material		
Type of heating system		
Heating control / regulation		
Domestic water heating		
Type of cooling system		
Energy demand [kWh/yr]		
Capital Costs	[UNIT: € , NOK, CZK]	Year of reference
Project costs		
Remaining costs		
Running Costs (excl. energy)	**[unit/year]**	
Administration		
Operating		
Maintenance		
Development		
Cleaning		
Energy Costs	**[unit/year]**	
Heating		
Cooling		
Electricity		

* input means the needed input for the database to categorise the building

** result means the calculated cost figures resulting from database information

German data collection sheet

Gebäudesteckbrief

Gebäudedaten	
Gebäudename / -adresse	Hauptgebäude
Gebäudenummer	1
Dienststellen	JVA Hakenfelde
Gebäudefläche (NGF)	2.316
Gebäudenutzung	Justizvollzugsanstalt
Refenrenztyp (Liegenschaft)	Justizvollzugsanstalten
Bautechnischer Zustand	
Baujahr	1985
Außenwand (Beschreibung + U-Wert)	Betonfertigteil mit Kerndämmung, U≈ 0,885 W/(m² x K)
Fenster (Beschreibung + U-Wert)	Holzrahmenfenster mit Isolierverglasung, U≈ 2,7 W/(m² x K), schlechter baulicher Zustand, undicht
Dach (Beschreibung + U-Wert)	Schrägdach mit Asbestplatten, oberste Geschossdecke gedämmt U≈ 0,52 W/(m² x K)
Kellerdecke (Beschreibung + U-Wert)	nicht unterkeller
Wärmeversorgung / Warmwasser / RLT	
Wärmeerzeuger / -verteilung	Wärmeversorgung über Erdgaskessel in nebenliegender Polizeischule, Unterstation in JVA (300 kW Heizung / 90 kW WWB)
Warmwasserbereitung / Verteilung	indirekt über oben genannten Kessel, Warmwasserspeicher 2x 1.500 Liter
RLT	keine RLT-Anlage vorhanden
Beleuchtung	
Beleuchtung	Leuchtstoffröhren mit EVG
Elektrische Großverbraucher	
Beleuchtung 6 Küchen mit 24 Kühltruhen für Insassen, 6 Herde (von 22:00 bis 6:00 geschlossen)	
Energiemanagement / Anlageninstandhaltung	
Heizkreisregelung vorhanden (Beimischschaltung, Regelsystem Samson Trovis 5476), Nachtabsenkung programmiert	
Sonstiges	
der gesamte Dachaufbau ist sehr mangelhaft, die Dachplatten bestehen aus Asbest, sollte schnellstmöglich saniert werden	

Example for German measures

		Energieträgerumstellung	Maßnahme 1	Maßnahme 2	Maßnahme 3
Angaben zum Gebäude					
LG Nr.		Kultur 2.05.a	Kultur 2.05.a	Kultur 2.05.a	Kultur 2.05.a
Gebäudenummer		0	1	0	0
Maßnahme Nr.		1	2	1	2
Gebäudename / -adresse		gesamte Liegenschaft	Hauptgebäude	gesamte Liegenschaft	gesamte Liegenschaft
Maßnahmen-Code		Kultur 2.05.a-0-1	Kultur 2.05.a-1-2	Kultur 2.05.a-0-1	Kultur 2.05.a-0-2
Bezugsgrößen, Liegenschaft					
Energieverbrauch, Strom[kWh/a]		250.000	250.000	250.000	225.000
Anschlussleistung, Strom [kW]		300	300	300	295
Energieverbrauch, Wärme [kWh/a]		330.000	330.000	-70.000	-70.000
Anschlussleistung, Wärme [kW]		1.000	1.000	900	900
bislang erreichte CO2-Einsparung		0%	29%	37%	48%
Maßnahmenbeschreibung					
Maßnahme Bescheibung qualitativ			Erneuerung Einfachfenster	Beleuchtungssanierung	Hydralischer Abgleich
Maßnahme Bescheibung quantitativ			200 St. , 800 m²	2000 Wannenleuchten	5% Einsparung Wärme
Maßnahmentyp			Erneuerung	Erneuerung	Optimierung
Bauteil		Wärmeerzeuger	Fenster	Beleuchtung	Heizungsekundärnetz
"Ohnehin"-Maßnahme (bereits in		nein	teilweise	teilweise	nein
Dringlichkeit der Maßnahme			Instandhaltungsrückstand	Empfehlung/kann	Empfehlung/kann
kurz / mittel / langfristig			mittelfristig	kurzfristig	kurzfristig
Hinweise / Freitext					
Energieträgerumstellung					
Energieträger, alt		Fernwärme			
Wärmemischpreis	Cent/kWh	11,123			
Emissionsfaktor	g/kWh	145			
Energieträger, neu					
Energieträger, neu		Fernwärme			
Verbrauch	kWh	330.000			
Leistung	kW	1.000			
Tarif		4. Zone			
Arbeitspreis	Cent/kWh	3,87			
Grundpreis	€/a	23.936			
Wärmemischpreis	Cent/kWh	11,123			
Emissionsfaktor	g/kWh	145			
Energieeinsparungen					
Einsparung Strom, Arbeit	kWh		0	25.000	20.000
Einsparung Strom, Leistung	kW		0	5	
Einsparung Wärme, Arbeit	kWh	0	400.000	0	75.000
Einsparung Wärme, Leistung	kW	0	100	0	
nsparung aus Nutzerverhalten, Strom, Arbeit	kWh				
sparung aus Nutzerverhalten, Wärme, Arbeit	kWh				
Reduzierung CO2-Emissionen Strom	t/a	0	0	15	12
Reduzierung CO2-Emissionen Wärme	t/a	0	58	0	11
Gesamtreduktion CO2-Emissionen	t/a	0	58	15	23
Kosten (Invest, Wartung und Instandhaltung)					
Investition gesamt	€	10.000	1.000.000	10.000	10.000
Investition Ohnehin-Maßnahme (vgl. Zeile 24)	€	0	120.000	0	0
Wartung/Instandhaltung	€ / a	0	200.000		
Wartung/Instandhaltung Änderung zu Bestand	€ / a	0	0	0	0
Lebensdauer	Jahre	15	50	20	10
Wirtschaftlichkeitsrechnung					
Stromkosteneffekt, Arbeit (Jahr 1)	€ / a		0	-3.000	-2.400
Stromkosteneffekt, Arbeit (Lebensdauer)	€		0	-54.291	-22.765
Wärmekosteneffekt, Arbeit (Jahr 1)	€ / a	0	-44.494	0	-8.343
Wärmekosteneffekt, Arbeit (Lebensdauer)	€	0	-1.755.819	0	-79.138
Kosteneffekt Strom und Wärme	€	0	-1.755.819	-54.291	-101.903
Kosteneffekt Wartung / Instandhaltung	€	0	0	0	0
Gesamtkosteneffekt (Lebensdauer)	€	0	-755.819	-44.291	-91.903
Annuität	€ / a	0	-35.184	-3.259	-11.331
Kosten je t CO2	€ / t	-	-607	-217	-495