Economical and Environmental benefits of Restoration

ACES-project. Work Package WP 2. Deliverable ACES-D2-1

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Work Package WP 2

Economic and Environmental

Benefits of Restoration

Joint Report

Deliverable ACES-D2-1

Edited by Per Anker Jensen

November 2013

CONTENT

1. INTRODUCTION

The ACES-project is a joint research project undertaken in collaboration between the 3 partners:

DTU: Technical University of Denmark, Lyngby, Denmark
KTH: The Royal Institute of Technology, Stockholm, Sweden
FRC: Frederick Research Center, Nicosia, Cyprus

The acronym ACES stands for "A Concept for promotion of sustainable retrofitting and renovation in Early Stages". The project is part of the European Eracobuild initiative and part of a program for Value Driven Processes. The project started September 2011.

The purpose of this document is to provide an overview of work package WP 2 of the ACES-project. WP 2 concerns: "Economic and environmental benefits of restoration". DTU represented by professor Per Anker Jensen, Centre for Facilities Management, DTU Management Engineering, has had the main responsibility for WP 2.

The activities have included a combination of qualitative and quantitative approaches. At DTU the focus has been on a qualitative approach based on interviews and case studies with the aim to develop the value based tool called RENO-EVALUE for formulation of objectives and holistic evaluation of building renovation, which takes the different interests and viewpoints of the main stakeholders into account. At KTH and FRC the focus has been on quantitative approaches with developing a model for calculation and simulation of economic and environmental impacts of building renovation, which have been tested in case studies.

WP 2 has included workshops with stakeholders in each country. In Denmark DTU has arranged 2 workshops and in both workshops there was participation and presentations from 2 of the project partners from KTH.

The deliverables related to WP2 has included 4 joint deliverables consisting of this joint report, 1 journal article and 2 conference papers, which has been produced in collaboration between all partners in the ACES project. These deliverables are in the following called ACES-D2-x. Besides, each of the partners has individually produced in total 5 national deliveries. These deliverables are in the following called DTU-D2-x, KTH-D2-x and FRC-D2-x, respectively. An overview of all 9 deliverables is provided in chapter 2 of this report.

Chapter 3 provides a description of the RENO-EVALUE tool and chapter 4 presents an example of an evaluation using RENO-EVALUE on a case study of a major on-going renovation project of a social housing estate in Denmark. English versions of the RENO-EVALUE templates concerning housing renovation projects are includes as appendices. Chapter 5 presents the FRC contribution to this work package through a short description of the deliverables that FRC was responsible for.

2. DELIVERABLES

2.1 DTU

DTU has had main responsibility for the following 2 joint deliverables.

ACES-D2-1: Economic and Environmental Benefits of Restoration. ACES-project. Workpackage WP 2. Joint Report.

This present report provides an overview of WP 2.

ACES-D2-2: Sustainability Evaluation of Retrofitting and Renovation of Buildings in Early Stages. Conference Paper.

The conference paper (Jensen et al., 2013) was presented at 7th Nordic Conference on Construction Economics and Organisation in Trondheim, Norway, June 2013. It provides the background, purpose, considerations and ideas for RENO-EVALUE.

DTU has also been responsible for the following 2 deliverables in Danish.

DTU-D2-1: RENO-EVALUE – et værdibaseret værktøj til målformulering og evaluering af bygningsrenovering (RENO-EVALUE – a value based tool for formulation of objectives and evaluation of building renovation.) Main Report.

The report (Jensen and Maslesa, 2013a) presents the detailed results concerning the Danish case studies and the development of RENO-EVALUE, including documentation of interviews and workshops.

DTU-D2-2: Energioptimering af kontorejendom med forbedring af energimærket som målsætning (Energy optimisation of office building with improvement of energy label as objective). Magazine Article.

The article (Maslesa and Jensen, 2013b) present a case study, where the tenant from a state organisation has required that the owner improves in the energy label of the office building as part of a renewal of the rental agreement.

2.2 KTH

KTH has had main responsibility for the following joint deliverable.

ACES-D2-3: On Stakeholders and the Decision Making Process Concerning Sustainable Renovation and Refurbishment in Sweden, Denmark and Cyprus. Journal Article.

The article (Gohardani et al., 2013) presents the results of the initial needs and stakeholder analysis undertaken in each of the 3 countries presented in the ACES project. This article outlines the decision making process related to sustainable renovation in buildings with emphasis of the attitude of stakeholders in Sweden, Denmark and Cyprus based on cases studies.

KTH has also been responsible for the following deliverables.

KTH-D2-1: Economic and environmental benefits related to a sustainable building refurbishment. Conference Paper.

This conference paper (Gohardani and Björk, 2012) provides an insight into the economic and environmental benefits related to a sustainable building refurbishment based on a case study of a multi-storey building. The conference paper is also published as part of a licentiate thesis (Gohardani, 2012).

KTH-D2-2: Turning building renovation measures into energy saving opportunities. Journal article.

The purpose of this study (Gohardani et al., 2013) was to investigate how to promote energy saving measures concurrent with planned major renovation/refurbishment in residential buildings. In this case the process of renovation in buildings owned by tenant owners' co-operatives was studied. The methodology comprised of case studies, in which the influence of various factors was identified for the overall decision making related to building renovation/refurbishment. In the process a specially committed energy expert was adopted to the team planning for the renovation in order to highlight the possibilities for energy savings

KTH-D2-3: Common inaccuracies in environmental certification applications in Sweden. Journal article.

The purpose of this study (Navid Gohardani, Ivo Martinac and Folke Björk, 2013) was to contribute to further understanding about the level of ability among building consultants, comprehension of environmental classification, and enhancement of the ability to produce high-quality calculations concerning building-related energy usage.

KTH-D2-4: A Simplified Approach Towards Net Zero Energy Buildings: The Early Stage Primary Energy Estimation Tool. Conference paper.

The purpose of this study (Navid Gohardani, Folke Björk, 2013) was to identify net zero energy buildings by means of a simplified calculation tool aimed at stakeholders, policy and decision makers. The primary energy required for a building can easily be estimated using ESPEET. Based on four distinct factors (input parameters, data processing, calculation of parameters, and decision based on model findings), this tool makes use of a number of required input parameters to estimate the primary delivered energy and the renewable energy ratio, for a building.

2.3 FRC

FRC has had main responsibility for the following joint deliverable.

ACES-D2-4: Promotion of Sustainable Renovation in Europe. Conference Paper.

The conference paper (Fokaides et al., 2013) presents the main aspects of initiatives in the field of energy upgrading of buildings in Europe today divided in political initiatives and research and other initiatives.

FRC has also been responsible for the following deliverables.

FRC-D2-1: Model for integrated and environmental evaluation of restoration. Report.

FRC-D2-2: Economic and environmental evaluation of the restoration measures. Report.

FRC-D2-3: Guidelines for restoration best practices. Report.

FRC-D2-4: Resources and tools for Cyprus. Report.

The main results of these four reports are summarised in chapter 5

3. RENO-EVALUE

3.1 Background

There are many challenges and obstacles in building renovations. Many possibilities are missed in the early stages of renovation projects because of the lack of knowledge and missing economic incentives, and there is also a need for a better communication between different stakeholders involved in building renovations. In order to overcome some of these issues, the new evaluation tool called value-based RENO-EVALUE has been developed.

Value is a complex concept – particular when we look beyond the quantifiable economic value and take qualitative aspects into consideration. Jensen et al. (2012) provides an overview of key terminology on value and value types. A common definition is that value is the trade-off between benefits ("what you get") and sacrifices ("what you give"). From this definition follows that value has a strong subjective element. Different people will evaluate benefits and sacrifices differently. This means that we in relation to value of building renovation need to focus on the different stakeholders and their different interests and viewpoints.

In the initial stage of the ACES-project a study of the state-of-the art of energy renovation of buildings in Denmark was conducted as part of WP 1(Jensen, 2011). This showed that there is a need for simple to use tools to support decision-making and evaluation of renovation projects. This was supported by the needs and stakeholder analysis made as part of WP2 (Gohardani et al., 2013).

3.2 Purpose

RENO-EVALUE is a tool for holistic assessment of sustainability in building renovation projects. The main purpose of RENO-EVALUE is to be used as a decision support tool in the early stages of renovation projects. It is a process-oriented tool that can be used by anyone with insight into the project. RENO-EVALUE is not only focusing on a final product, but covers project organisation, economy and renovation process too. It can be used to formulate goals for renovation projects and to enable focus on essential aspects for the primary decision makers. It can also be used as a communication tool between different stakeholders and help in making evaluations on the basis of expectations. The tool has to be able to monitor and evaluate the obtained results and also to provide the opportunity to compare different projects and evaluate alternative proposals. RENO-EVALUE is also planned to be used to illustrate cases in the form of inspirational projects.

3.3 Target group

RENO-EVALUE can be used by the decision-makers who not necessarily possess the adequate technical competences for evaluating the energy renovation projects. The tool can be used by all stakeholders involved in the early stages of building renovation project, as long as they have some knowledge about the project.

The evaluation tool is intended for use on large scale projects in the professional sector, not single family houses etc. Primary users of RENO-EVALUE might be client organisations, housing associations, estate administrators, facilities managers etc. One of the advantages of RENO-EVALUE is that it can be used as a communication tool between developers/landlords and representatives of inhabitants, tenants, employees and building users. It can also be used by project managers to manage the expectations of the different stakeholder and to show to which degree the objectives have been met. Architects, consultants and contractors might use RENO-EVALUE for illustrations and comparisons of different proposals.

3.4 Application method

Since the tool is addressing different stakeholder groups, it has to be easy to understand and simple to use. Data is collected through interviews with primary stakeholders and there are no new calculations in the tool. An interviewer collects facts about the project beforehand and checks them with the stakeholders during the interviews. Interview questions are standardized with minor deviations depending on stakeholders and building types.

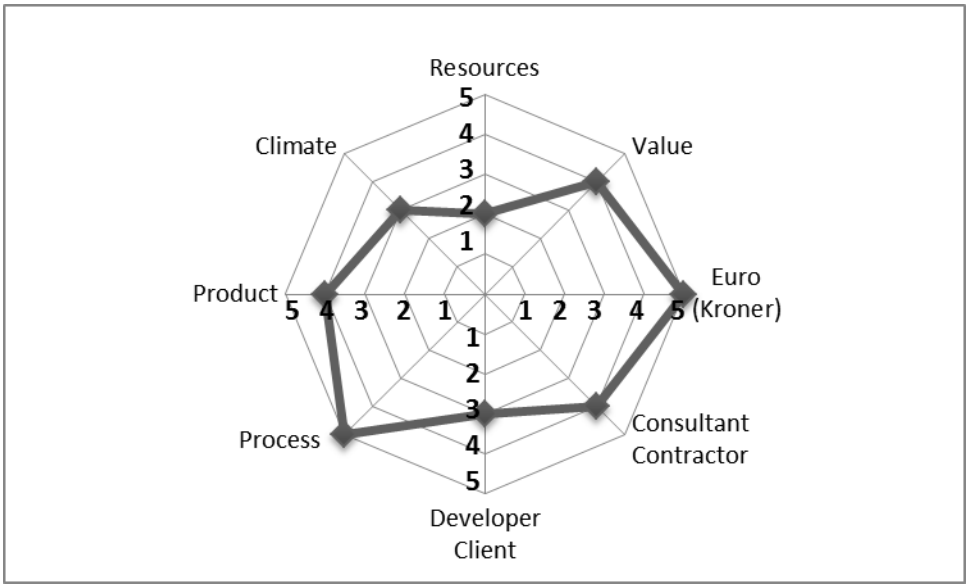

Figure 1: Illustration of RENO-EVALUE model

The evaluation of a project is based on subjective assessments, but also supported by project facts. Furthermore, there is a written explanation for a certain rating and the information about valuator is available too.

The RENO-EVALUE model is in Figure 1 illustrated as a spider's web in which it is possible to rate parameters and their factors with grades 1-5 from low to high. It is possible to make the rating both before and after the energy renovation is completed, which in the end makes it possible to compare the expectations with the final results. The advantages of RENO-EVALUE are that it does not take long time to do the evaluation, the graphical illustration of results is easy to understand, and the model provides a quick overview of the current situation, seen from a certain stakeholder's perspective. It can for instance be useful in the early stages of the energy renovation projects, in order to improve the matching of expectations between different stakeholders and defining the success criteria for a project. After the project is completed, the evaluation results from the initial phase can be used to determine whether the success criteria are fulfilled or not, and there is also possibility to evaluate the project again. The evaluations can internally be used to compare "before and after" situation, and externally for experience exchange and comparison between different projects.

3.5 Parameters in the tool

The evaluation tool RENO-EVALUE covers the four main categories: Environment, Users, Project organisation and Economy. Each category is divided in two parameters with a subdivision in a number of factors. The categories and the parameters are generic in relation to building types, while some of the factors are dependent on the specific building types. Factors are shown for each category and parameter in Table 1. This is based on renovation of housing estates, which for instance is expressed in the factors for "Value".

Table 1: Categories, parameters and factors in RENO-EVALUE

Category	Parameter	Factors
Environment	Resources	Energy consumption Renewable energy production Water consumption Reuse of water Reuse of building materials Amount of waste Reuse of waste
	Climate	CO_2-emissions Pollution Local discharge of water
Users	Product	Architecture and aesthetics Function and user-friendliness Indoor climate and comfort Sustainability
	Process	Cooperation between participants Mutual information User involvement User consideration in implementation
Project Organisation	Developer/client	Project management skills Ability for decisions Technical competence Cooperative skills Involvement of the operating organisation Risk/responsibility/innovation
	Consultant/contractor	Project management skills Technical competences Problem solving abilities Cooperative skills Coherence in supply team Risk/responsibility/innovation
Economy	Euro/Kroner	Reasonable rent Reasonable running costs Reasonable costs in the long term
	Value	Desirable dwelling Well-functioning estate Attractive area

4. EXAMPLE OF USAGE OF RENO-EVALUE

4.1 Case with renovation of a social housing estate

The social housing estate Sorgenfrivang II consists of 3 high-rise buildings of 15 storeys placed near Sorgenfri Station in the suburb Virum 20 km north of Copenhagen city. The estate has 428 flats covering 9 different types (1-6 rooms), and it is a department in a housing association. The estate was occupied during 1957-59 and the total floor area is 45.000 m^2. An aerial view of the estate is shown in Figure 2.

Figure 2: Aerial view of Sorgenfrivang II.

The local municipality has classified the estate as worth preserving, which means the architectural appearance of the high-rise blocks cannot be changed radically. Over the years a major maintenance backlog has been established and there is an urgent need for a major renovation of the estate. The buildings have many technical challenges like limited insulation and leaky facades, problems with mould fungus, cold bridges etc. as well as visible concrete damages. Besides these challenges there is also a need for functional improvements. The lifts are worn down and only stops at every second floor. The plumbing is old and out-dated, and the balconies are very small. Besides being of annoyance for the tenants these disadvantages also has a negative effect on the energy consumption.

The planning of the renovation project started in 2008 and the process has been long and troublesome, including a change of consultants and major alterations of the project As part of the preparation of the renovation a master plan has been produced. In 2012 the national Danish Building Foundation (Landsbyggefonden) offered to support the project based on the

master plan. In October 2012 a great majority of the tenants accepted the project, including a major rent increase when the project is finished.

The total cost of the project is 511 million DKK (68 million Euro). The rent will increase from 688 DKK/m^2/year in 2012 to 953 DKK/m^2/year (from 92 to 127 Euro/m^2/year) after the renovation - equivalent to 38.5 %. However, the increased rent is at the same level as similar housing estates in the area. The energy consumption is expected to be reduced by up to 66% from 89.9 to 30.6 kWh/m^2/year. After the decision was taken in October 2012, the detailed design of the project started. The renovation project is planned to be finished by the end of 2016.

4.2 RENO-EVALUE description and evaluations

The case study is based on interviews with the main stakeholders during 2012 before the decision and evaluations by the same stakeholders after the decision in late 2012 and early 2013. A standardised description of the renovation based on the parameters and factors in the RENO-EVALUE tool was prepared by the ACES researchers and is shown in Table 2. The stakeholders' evaluation of each of the 8 parameters is shown in Figure 3.

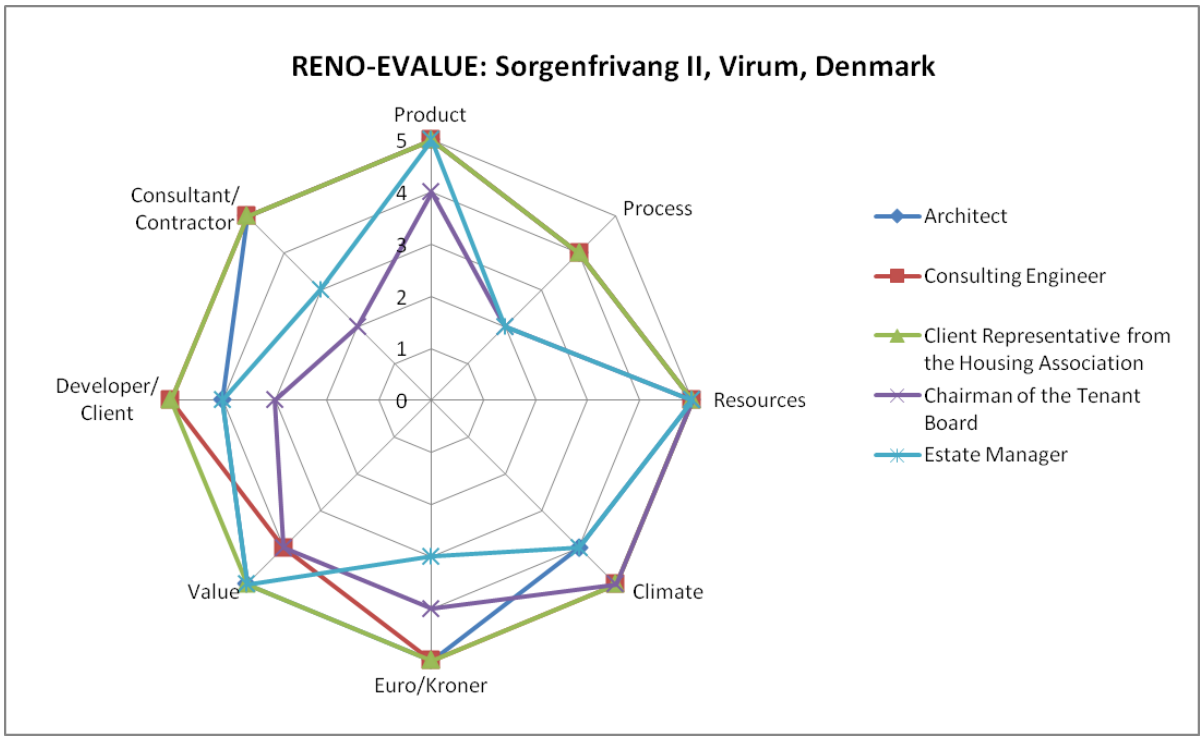

Figure 3: RENO-EVALUE evaluations of Sorgenfrivang II.

Table 2: RENO-EVALUE description of Sorgenfrivang II (page 1 and 2)

Category	Parameter	Factors	Preconditions
Stakeholders	Product	Architecture and aesthetics	• *Important to keep the architectural expression*
		Function and usability	• *Larger balconies (50 %) and lifts* • *New kitchens and bathrooms* • *Glass covering of stairwells.*
		Indoor climate and comfort	• *Less draught/cold bridges* • *Improved temperature regulation* • *More daylight/improved outlook* • *Mechanical ventilation*
		Durability/future securing	• *New facades and installations with long lifetime (min. 30 years)* • *Comply with current energy requirements*
	Process	Collaboration between partners	• *Based on traditional principles*
		Mutual information	• *Follows traditional principles*
		Involvement of users	• *Workshops in 3 groups on different topics* • *Tenants meeting with voting*
		Considerations for users during construction	• *Tenants can stay during renovation*
Environment	Resources	Energy consumption	• *Expected reduction from 89.9 kWh/m^2/year to 30.6 kWh/m^2/year – up to 66 % in average* • *Energy label improvement from D to A.* • *Greatest effect by replacing windows (38 %) and glass covering of stairwells (22 %)*
		Renewable energy production	• *900 m^2 photo voltaic cells on roofs* • *Expected effect: 135.000 kWh/year*
		Water consumption	• *Rain water collection on low buildings*
		Reuse of water	• *Rain water for laundry*
		Reuse of building materials	• *Not known*
		Amount of waste	• *No changes – waste suction system was installed in 2002.*
		Reuse of waste	• *No changes*
	Climate	CO2 emission	• *CO2 reduction not estimated.* • *CO2 neutral laundry.* • *Renewable energy production (photo voltaic cells on roof))* • *Reuse of rain water* • *Energy saving lighting in common areas*
		Pollution	• *Not estimated – indirect effects of the above mentioned measures*
		Local discharge of water	• *Not known*

Category	Parameter	Factors	Preconditions
Economy	Euro/ Kroner	Reasonable rent	• *Considerable rent increase of 38.5 %, but from a low present level.*
		Reasonable running cost	• *Considerable reduction in heating cost* • *Reduced expenses of external maintenance in a number of years.*
		Reasonable cost in the long term	• *Depends on financing and price development (inflation + energy prices)* • *Probably not major other rent increases for a long period (assumption)*
	Value	Desirable dwelling	• *Modern buildings – updated to present standard.* • *Green image from environmental measures (photo voltaic cells on roofs)* • *New kitchens and bathrooms*
		Well-functioning estate	• *Improved access areas and lifts*
		Attractive area	• *Architectural upgrading*
Project Organisation	Developer/ client	Project management skills	• *Large, professional housing association as client representative*
		Ability for decisions	• *Very engaged tenant board* • *Great political attention locally*
		Technical competence	• *Based on external consultants*
		Cooperative skills	• *On-going collaboration based on a frame agreement with the main consultant*
		Involvement of the operating organisation	• *Represented in the building committee.*
		Risk/responsibility/innovation	• *Large building committee.*
	Consultant/ contractor	Project management skills	• *Main consultant selected based on a frame agreement.*
		Technical competence	• *The current consultant has been selected to replace a former consultant* • *Both architect and consulting engineer have extensive experiences with large housing renovation projects* • *Both consulting engineer and architect apply energy simulation tools.* • *Both architect and consulting engineer apply a sustainability triangle tool*
		Problem solving ability	• *Not known.*
		Cooperative skills	• *Consulting engineer and architect company have collaborated on earlier projects* • *Both consulting engineer and architect are represented by a partner in the project organisation.*
		Coherence in supply chain	• *The consulting engineer company is main consultant with the architect company as sub-consultant* • *The architect has been selected in agreement between the client representative and the main consultant*
		Risk/responsibility/innovation	• *The project is now in the design phase* • *The contractor has not been selected yet.* • *Long construction period (3 years) – possibility for improvements and innovations along the way.*

Figure 3 shows that the 5 actors agree on some parameters and disagree on others. All of the actors agree that the renovation will make the estate much more environmentally friendly with regards to resources (grade 5) and the expected energy saving of 66 % is referred to as the most important argument.

The viewpoints concerning the process are quite differentiated. While the architect, the consulting engineer and the client representative from the housing association characterise the process as "better than could be expected" (grade 4), the chairman of the tenant board and the estate manager characterise the process as "worse than could be expected" (grade 2). The arguments given by the first group include expressions like "*Engaged tenants, client and consultants*" and "*Excellent collaboration*", while the second group experience the situation very differently with expressions like "*The start phase went well, but in the final phase the situation has changed*" and that "*There has not been a wish to involve the tenants*".

The evaluations of consultant/contractor are also quite differentiated between the same two groups. The architect, the consulting engineer and the client representative assess the organisation on the consultant part to be "very suitable" (grade 5), while the chairman of the tenant board and the estate manager assess the consultant part as "acceptable" (grade 3) and "unsuitable" (grade 2), respectively. The arguments for the high grades are "*Very engaged, curious and professional team*" og "*Exceptionally engaged and professionally competent*", while the lower grades are explained by "*They (the consultant team) are excluding and do not always hear what we want and wish*" and "*They should learn to practice tenant involvement*".

5. FRC Contribution

This section presents the contribution of Frederick Research Center to this work package. FRC was responsible for four deliverables which are briefly described below.

5.1 FRC-D2-1: Model for integrated and environmental evaluation of restoration

This report (Frederick Research Center, 2012) presented the results of a quantitative evaluation of three case study buildings in Cyprus. The evaluation was based on the Consolis Energy+ software which was developed by KTH. The software is based on an integrated evaluation model with combination of Life Cycle Assessment (LCA) and Whole Life Costing (WLC).

The selected case studies were a two storey detached building, a five storey building and a five storey detached office building. For all investigated case studies, the following values were calculated:

- Total Energy Need for Heating
- Total Cooling Energy
- Total Energy for Heating & Cooling
- Property- and household electricity
- Hot water
- Energy sum
- Energy Need for Heating per m²
- Cooling Energy per m²
- Energy for Heating & Cooling per m²
- Property-and household electricity per m²
- Hot water per m²
- Energy sum
- Energy saving Heating %
- Energy saving Cooling%
- Total Energy saving %
- Energy saving Heating (KWh)
- Energy saving Cooling (KWh)
- Total Energy Saving (KWh)
- Energy saving Heating (€)
- Energy saving Cooling (€)
- Total Energy saving (€)
- Total Renovation Cost
- Payback Period (simple)
- Payback Period (regarding inflation, interest etc.)
- Net Present Value of Investment
- Equivalent liters of heating oil (consumption)
- Equivalent liters of heating oil (saving)

For the calculation of the pay-back period, as well as the net present value of all insulation expenses, the corresponding tool of the Cyprus Ministry of the Energy Service of the Ministry of Commerce, Industry and Tourism ("Tool for evaluation of the profit and loss for energy upgrade measures of new and existing buildings") was employed. In all cases, the following assumptions were made:

- Heating oil cost: 0.99 €/lt
- Electricity cost: 0.20 €/kWh
- Loan maturity: 15 years

- Loan interest: 2%

Twelve scenarios based on different combinations of building elements and materials were examined for each of the three case studies. The most energy and cost efficient solutions as obtained from the results regarding the energy performance of the buildings were further combined and examined, and six further scenarios were investigated. Finally, the most cost and energy efficient solutions were proposed.

5.2 FRC-D2-2: Economic and environmental evaluation of the restoration measures

The report (Frederick Research Center, 2013a) evaluated the possible measures that can be applied in a building restoration process. Those measures were evaluated by means of their economic impact in the restoration process as well as the environmental benefits obtained through their application. The evaluation focused on measures regarding the thermal insulation of the walls and the roof as well as the upgrading of windows. Different case studies, thirteen in total, of each proposed measure were evaluated, considering the cost per unit area and the energy savings as a result of the application of each measure.

The investigated restoration measures that were evaluated are listed below:

- Window upgrading:
  - RM0: Single glazing
  - RM1: Double glazing, profile with no thermal break
  - RM2: Double glazing, profile with thermal break
  - RM3: Double glazing, profile with thermal break, low emissivity internal glass
  - RM4: Double glazing, profile with thermal break, low emissivity internal glass, Argon within the double glazing gab
  - RM5: Double glazing, profile with thermal break, low emissivity internal glass, Argon within the double glazing gab (higher profile properties)

- Roof insulation:
  - RM6: Insulation thickness, 30 mm
  - RM7: Insulation thickness, 50 mm
  - RM8: Insulation thickness, 80 mm
  - RM9: Insulation thickness, 100mm

- External Walls insulation:
  - RM10: Insulation thickness, 30 mm
  - RM11: Insulation thickness, 50 mm
  - RM12: Insulation thickness, 80 mm
  - RM13: Insulation thickness, 100mm

The renovation cost for each restoration measure is shown in Figure 4.

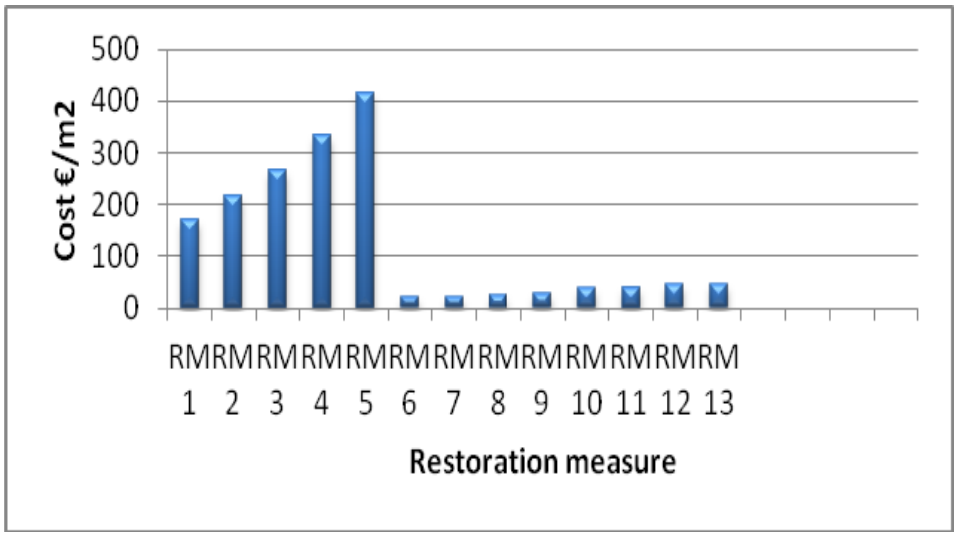

Figure 4: Renovation cost per m² (€/m²)

Based on the results of the evaluation, a combination of the most cost and energy efficient measures was further examined.

5.3 FRC-D2-3: Guidelines for restoration best practices.

This report (Frederick Research Center, 2013b) proposed some guidelines for restoration best practices in order to support the effort for the improvement of the energy performance and mitigation of energy consumption of existing buildings.

The technical measures that can be applied on an existing building and that were proposed in the report are listed below:

- Insulation of vertical building elements
- Roof insulation
- Basement ceiling insulation
- Window replacement
- Measures regarding the HVAC systems (Replacement of existing boiler, replacement of air handling units, installation of heat recovery systems etc.)
- Lighting
- Measures for the utilization of solar energy: (Solar thermal systems, PV solar systems)

5.4 FRC-D2-4: Resources and tools for Cyprus

The report (Frederick Research Center, 2013c) presents a Cyprus software tool, Sbem, which is used for Energy Performance Calculation, applied in seven different case studies of buildings. The case studies were selected through an overview of the results of previous studies that investigated the building stock of Cyprus. The selection of the construction materials of the seven case studies was based on the findings of the research project "Categorization of buildings in Cyprus based on their energy efficiency" (ΑΕΙΦΟΡΙΑ/ΑΣΤΙ/0308 (BIE)/02) and represent more than 90% of the Cyprus building stock, constructed prior to 2007. The selected building elements which are applied on the seven buildings consist of two different types of masonry, external roof, and floor as well as two different types of windows.

Table 3 below presents the combinations of building elements as applied on the seven case study buildings.

Table 3: Construction characteristics of seven case study buildings

Building Element	Building 1	Building 2	Building 3	Building 4	Building 5	Building 6	Building 7
Masonry 1	❶	❷	❸	❹	❺	❻	
Masonry 2							❼
Roof 1	❶		❸			❻	❼
Roof 2		❷		❹	❺		
Floor 1	❶	❷				❻	❼
Floor 2			❸	❹	❺		
Window 1	❶	❷	❸	❹			❼
Window 2					❺	❻	

An example of the results for each case study as obtained from Sbem calculation for each case study is presented in Table 4:

Table 4: Case study results

	Heating	Cooling	Auxiliary	Lighting	Hot Water	Total
	kWh/m2/yr					
Actual	60.24	123.14	0	15.19	6.73	205.3
Reference	3.99	30.82	3.05	18.72	29.23	85.8
	Ref B-C	**Actual**	**EPC label**			
kWh/m2/yr	184.9	457.94	E			
kgCO2/m2/yr	98.29	130.18	2.477			

Furthermore, the energy consumptions of each case study were presented and examined as shown in Figure 5 below.

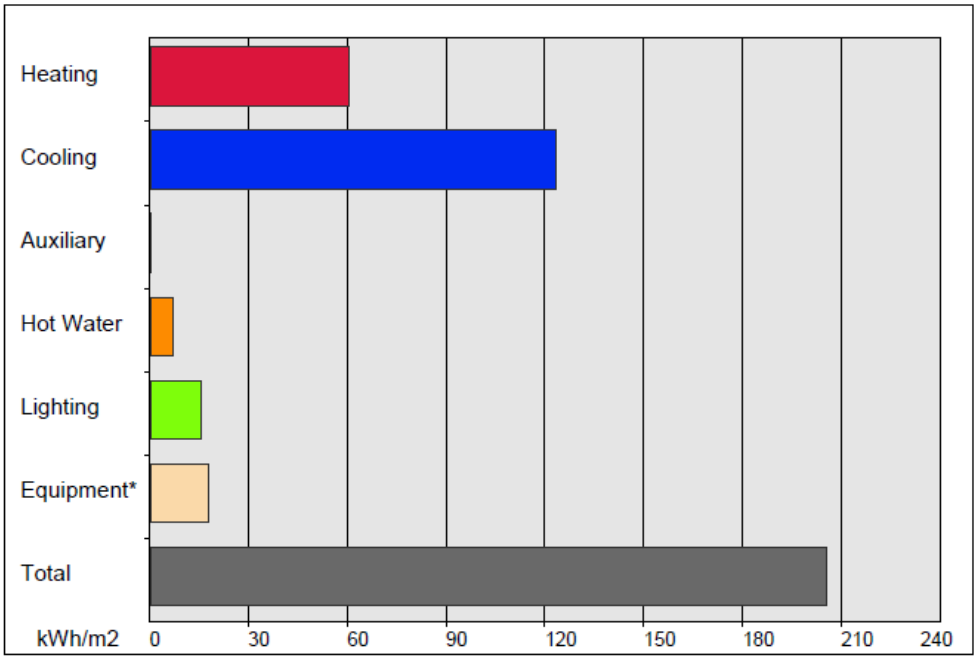

Figure 5: Annual energy consumption

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KTH: http://www.diva-portal.org - search for Gohardani.

APPENDICES: RENO-EVALUE TEMPLATES

The following 3 templates are for most aspects generic in relation to building types. However, a few formulations are specific for housing renovation projects. For instance, in the preconditions template in appendix 1, the factors related to the parameter "Value" on page 2 are specific for housing renovation projects. The templates can easily be adapted to fit other specific building types.

APPENDIX 1: PRECONDITIONS TEMPLATE – PAGE 1

Category	Parameter	Factors	Preconditions
Stakeholders	Product	Architecture and esthetics	
		Function and usability	
		Indoor climate and comfort	
		Durability/future securing	
	Process	Collaboration between partners	
		Mutual information	
		Involvement of users	
		Considerations for users during construction	
Environment	Resources	Energy consumption	
		Renewable energy production	
		Water consumption	
		Reuse of water	
		Reuse of building materials	
		Amount of waste	
		Reuse of waste	
	Climate	CO_2 emission	
		Pollution	.
		Local discharge of water	

APPENDIX 1: PRECONDITIONS TEMPLATE – PAGE 2

Category	Parameter	Factors	Preconditions
Economy	Euro/ Kroner	Reasonable rent	
		Reasonable running cost	
		Reasonable cost in the long term	
	Value	Desirable dwelling	
		Well-functioning estate	
		Attractive area	
Project Organisation	Developer/ Client	Project management skills	
		Ability for decisions	
		Technical competence	
		Cooperative skills	
		Involvement of the operating organisation	
		Risk/responsibility/innovation	
	Consultant/ Contractor	Project management skills	
		Technical competence	
		Problem solving ability	
		Cooperative skills	
		Coherence in supply chain	
		Risk/responsibility/innovation	

APPENDIX 2: OBJECTIVES SCORE CARD – PAGE 1

Category	Parameter	Objective / priority		Measures / reasoning
Stakeholders	Product	*What influence do you wish, or could you accept, the renovation to have on the functional and technical quality of the dwellings and the estate in the future?*		• *What are the most important measures to achieve this objective / reasons for this priority?*
		1: Much less quality 2: Less quality 3: No difference 4: Higher quality 5: Much higher quality	Grade:	
	Process	*How do you wish, or could you accept, the process of the renovation project to be in comparison with what you think that one reasonably could expect?*		• *What are the most important measures to achieve this objective / reasons for this priority?*
		1: Much worse that one could expect 2: Worse that one could expect 3: As one could expect 4: Better that one could expect 5: Much better that one could expect	Grade:	
Environment	Resources	*What influence do you wish, or could you accept, the renovation to have on, how environmentally friendly the estate will be with regards to resource consumption in the future?*		• *What are the most important measures to achieve this objective / reasons for this priority?*
		1: Much less environmentally friendly 2: Less environmentally friendly 3: No difference 4: More environmentally friendly 5: Much more environmentally friendly	Grade:	
	Climate	*What influence do you wish, or could you accept, the renovation to have on, how environmentally friendly the estate will be with regards to climate impact in the future?*		• *What are the most important measures to achieve this objective / reasons for this priority?*
		1: Much less environmentally friendly 2: Less environmentally friendly 3: No difference 4: More environmentally friendly 5: Much more environmentally friendly	Grade:	

APPENDIX 2: OBJECTIVES SCORE CARD – PAGE 2

Category	Parameter	Objective / priority		Measures / reasoning
Economy	Euro/ Kroner	*How reasonable do you wish, or could you accept, that the economic consequences of the renovation in the short and in the long term?*		• *What are the most important measures to achieve this objective / reasons for this priority?*
		1: Very unreasonable 2: Unreasonable 3: Acceptable 4: Reasonable 5: Very reasonable	Grade:	
	Value	*What influence do you wish, or could you accept, that the renovation should have on, how attractive the dwellings, estate and the area will be in the future?*		• *What are the most important measures to achieve this objective / reasons for this priority?*
		1: Much less attractive 2: Less attractive 3: No difference 4: More attractive 5: Much more attractive	Grade:	
Project Organisation	Developer/ Client	*How do you wish, or could you accept, the suitability of the organisation to be concerning the developer/client part in the renovation?*		• *What are the most important measures to achieve this objective / reasons for this priority?*
		1: Very unsuitable 2: Unsuitable 3: Acceptable 4: Suitable 5: Very suitable	Grade:	
	Consultant/ Contractor	*How do you wish, or could you accept, the suitability of the organisation to be concerning the consultant/contractor part in the renovation?*		• *What are the most important measures to achieve this objective / reasons for this priority?*
		1: Very unsuitable 2: Unsuitable 3: Acceptable 4: Suitable 5: Very suitable	Grade:	

Recommendation for setting priorities

It is recommended that the stakeholders that participate in setting objectives and making prioritisations by use of the objective score card are given a limited number of points to distribute as grades on the 8 RENO-EVALUE parameters. The range of scores is from 8 to 40 points for all 8 parameters, and the medium score is 3 for each parameter. This means that 24 points will force the participants to even out higher and lower grades, while 32 points will limit the number of very high scores. Another way to force the participants to prioritise is to maximise the number of possible high grades, for instance a maximum of 2 grades of 5 and 4 grades of 4.

APPENDIX 3: EVALUATION SCORE CARD – PAGE 1

Category	Parameter	Question / grade		Explanation / reasoning
Stakeholders	Product	*What influence will the renovation have for the functional and technical quality of the dwellings and the estate in the future?*		• *What is the most important reason to give this grade?*
		1: Much less quality 2: Less quality 3: No difference 4: Higher quality 5: Much higher quality	Grade:	
	Process	*How have you experienced the process so far and the plans for the further process during the renovation compared to what you think that one reasonably could expect?*		• *What is the most important reason to give this grade?*
		1: Much worse that one could expect 2: Worse that one could expect 3: As one could expect 4: Better that one could expect 5: Much better that one could expect	Grade:	
Environment	Resources	*What influence will the renovation have for, how environmentally friendly the estate will be with regards to resource consumption in the future?*		• *What is the most important reason to give this grade?*
		1: Much less environmentally friendly 2: Less environmentally friendly 3: No difference 4: More environmentally friendly 5: Much more environmentally friendly	Grade:	
	Climate	*What influence will the renovation have for, how environmentally friendly the estate will be with regards to climate impact in the future?*		• *What is the most important reason to give this grade?*
		1: Much less environmentally friendly 2: Less environmentally friendly 3: No difference 4: More environmentally friendly 5: Much more environmentally friendly	Grade:	

APPENDIX 3: EVALUATION SCORE CARD – PAGE 2

Category	Parameter	Question / grade		Explanation / reasoning
Economy	Euro/ Kroner	*How reasonable are the economic consequences of the renovation in the short and in the long term?*		• *What is the most important reason to give this grade?*
		1: Very unreasonable 2: Unreasonable 3: Acceptable 4: Reasonable 5: Very reasonable	Grade:	
	Value	*What influence will the renovation have for how attractive the dwellings, estate and the area will be in the future?*		• *What is the most important reason to give this grade?*
		1: Much less attractive 2: Less attractive 3: No difference 4: More attractive 5: Much more attractive	Grade:	
Project Organisation	Developer/ Client	*How do you asses the suitability of the organisation on the developer/client part in the renovation projects?*		• *What is the most important reason to give this grade?*
		1: Very unsuitable 2: Unsuitable 3: Acceptable 4: Suitable 5: Very suitable	Grade:	
	Consultant/ Contractor	*How do you asses the suitability of the organisation on the consultant/contractor part in the renovation projects?*		• *What is the most important reason to give this grade?*
		1: Very unsuitable 2: Unsuitable 3: Acceptable 4: Suitable 5: Very suitable	Grade:	