UNIVERSITY OF MINHO
SCHOOL OF ENGINEERING
CIVIL ENGINEERING DEPARTMENT

IEA EBC Annex 56

Cost-Effective Energy and Carbon Emissions Optimisation in Building Renovation

2010-2016

Participating Countries (12): AT, CH, CN, CZ, DK, ES, FI, IT, NL, NO, PT, SE

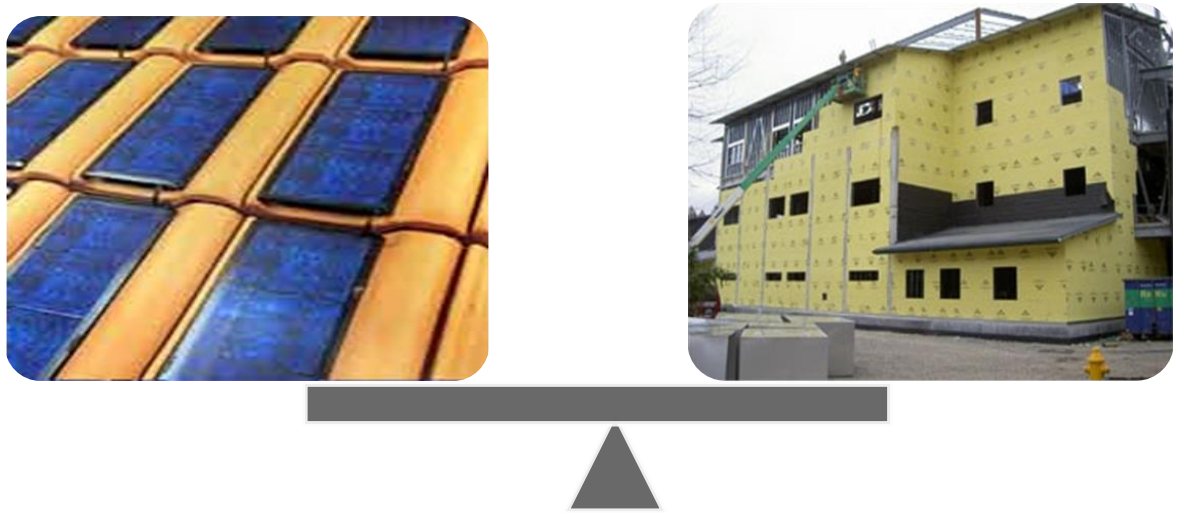
OA: Manuela Almeida
University of Minho
Portugal

Clima 2016 – WS28
Aalborg
24 May 2016

IEA EBC Annex 56 | Background

In existing buildings, the most cost-effective renovation solution is often a combination of energy efficiency measures and carbon emissions reduction measures.

So, it is relevant to investigate where is the balance point between these two types of measures in a cost/benefit perspective.



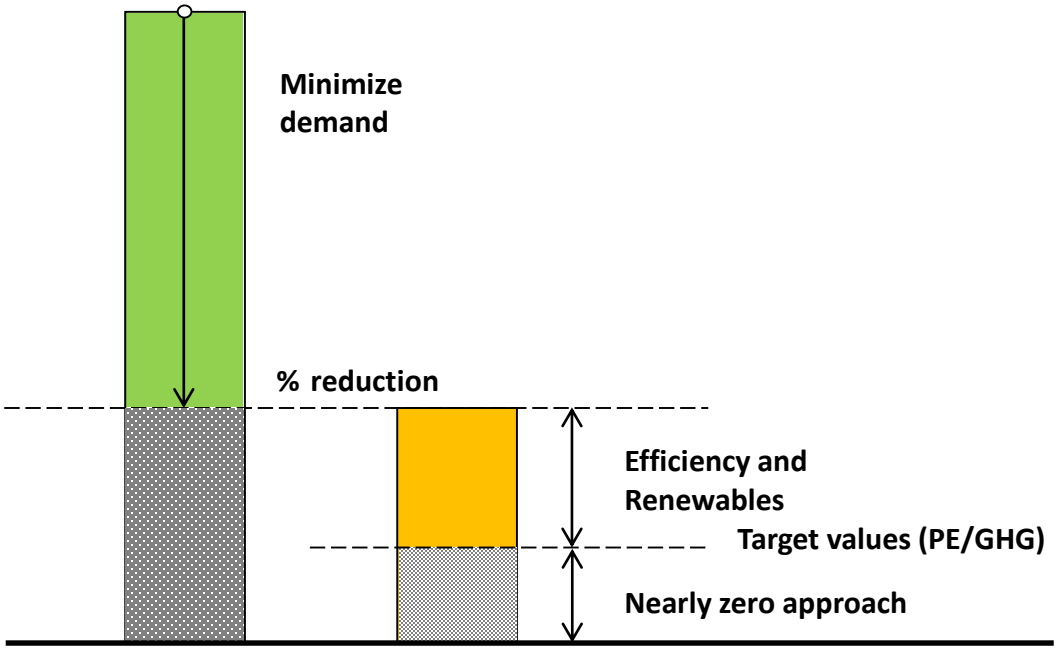
Question?

How to achieve the best performance with minimal effort?

IEA EBC Annex 56 | Main Goals

Develop a new methodology for a cost optimal building renovation towards both the nearly zero energy and nearly zero emissions objective

Identify the optimal balance between the "minimization of demand" and "generation of renewable energy" measures in a cost/benefit perspective



Questions?

How far it is possible to go with energy conservation and efficiency measures (initially often less expensive measures) and

From which point the carbon emissions reduction measures become more economical

IEA EBC Annex 56 | Main Objectives

- **Define a** methodology for the establishment of cost optimized targets for energy and carbon emissions **in building renovation**
- Clarify the relationship between the emission and the energy targets **and their eventual hierarchy**
- **Determine** cost effective combinations **of** energy efficiency measures **and** carbon emissions reduction measures
- **Highlight the relevance of** co-benefits achieved **in the renovation process**
- **Collect** exemplary case-studies **within the concept of Annex 56** to encourage decision makers **to promote efficient and cost effective renovations**
- **Characterize and understand the** acceptance, motivation, needs, obstacles and drivers **of the renovation process**
- **Develop/Adapt** tools to support the decision makers **in accordance with the developed methodology (including the production of a Renovation Guidebook an the adaptation of the Danish ASCOT Tool)**

IEA EBC Annex 56 | Scope

- **Residential buildings**
  Single-family houses and multi-family buildings

- **Non residential buildings without complex HVAC systems**

  - if relevant and useful information can be extracted from them

  - used to prove the applicability of the developed methodology and tools to other buildings' categories (besides residential buildings)

Bairro Rainha D. Leonor, Porto, PT

Primary school – Svážná 9, Brno, CZ

IEA EBC Annex 56 | Target Groups

Policy makers

To define the most appropriate policies, measures and incentives to put into practice for an effective renovation strategy

Decision makers (professional owners, investors, promoters)

To make better decisions and choose the best renovation options that apply to their needs

Multipliers (architects, planners, consultants and professionals of construction and building renovation industry)

Technical guidance

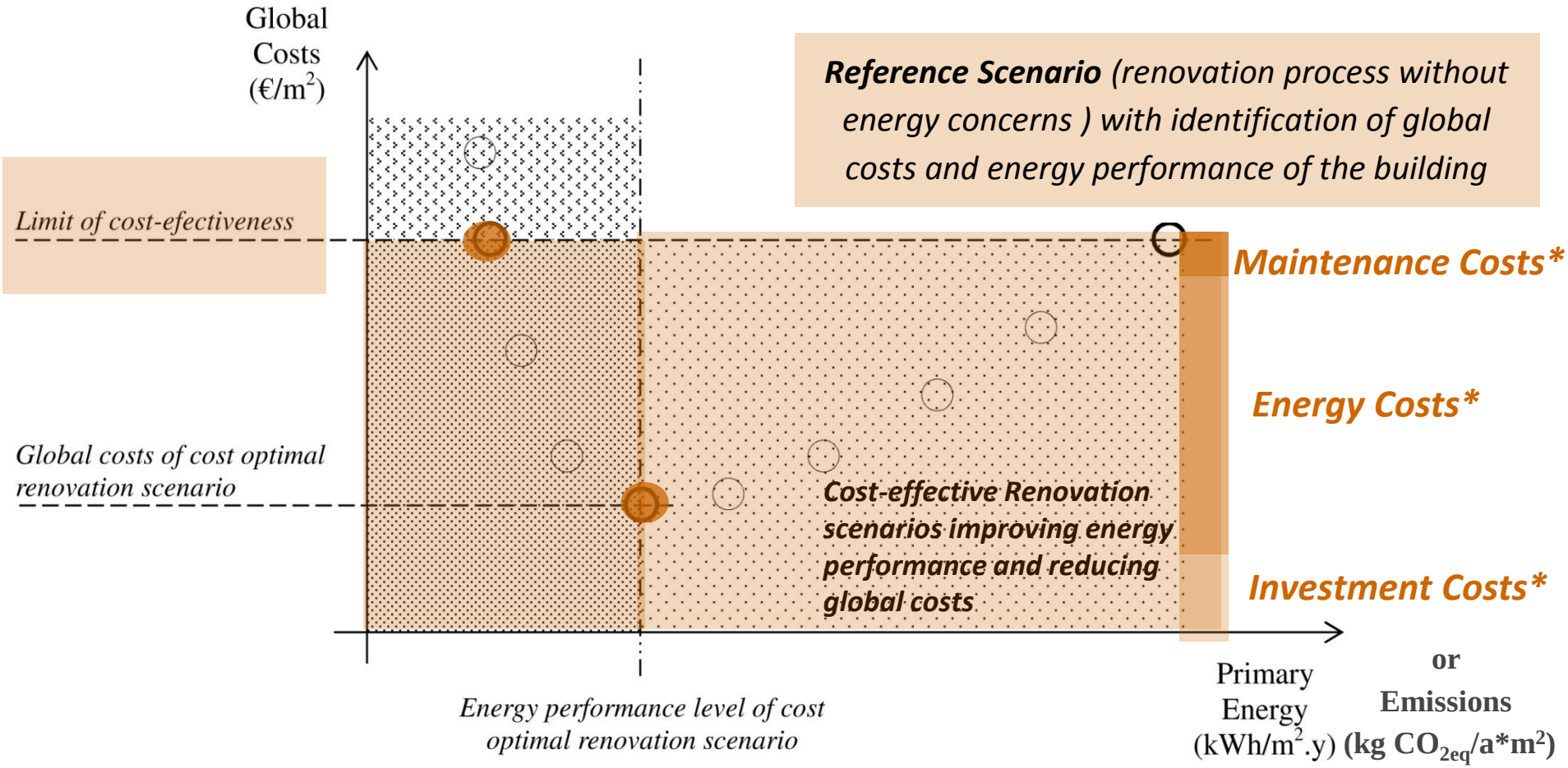
IEA EBC Annex 56 | Methodology

- Takes into account country specific situations (like climate, electricity mix, conversion factors, national energy targets, etc.)
- Allows prioritizing either nearly-zero emissions renovation (NZEmB) or nearly-zero energy renovation (NZEB) , each with an additional energy or emission goal that has to be achieved at the same time
- In any situation there is a strong requirement to make sure that substantial energy reductions must be achieved whatever the priority chosen
- It also evaluates life cycle impacts like embodied energy use and take into consideration, as much as possible, the co-benefits associated to the renovation process

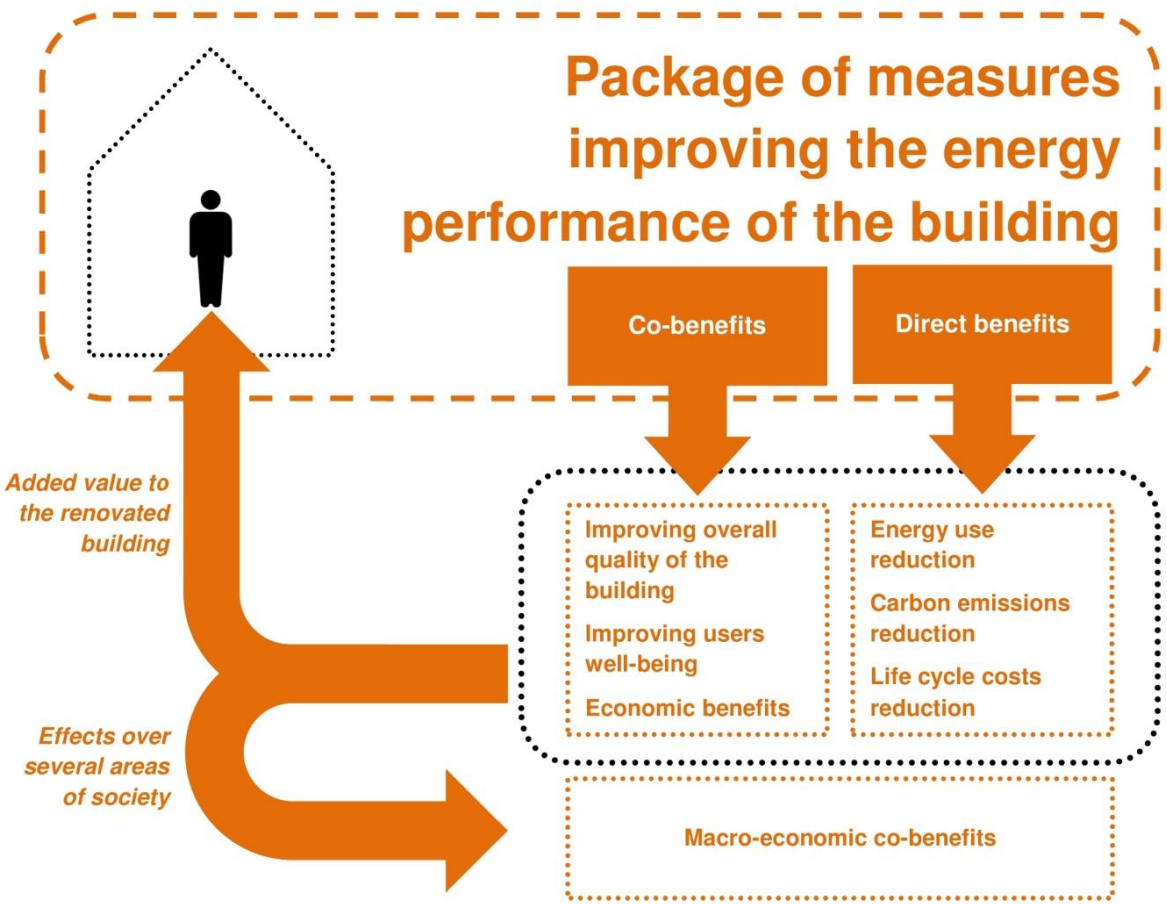
IEA EBC Annex 56 | Methodology

** Costs assessed for the building life cicle – 30 years*

Reference Scenario *(renovation process without energy concerns) with identification of global costs and energy performance of the building*



IEA EBC Annex 56 | Co-Benefits



Besides energy, emissions and costs reductions, the co-benefits are relevant because:

- ***Increase the added value of the building (relevant for owners);***
- ***have effects over several areas of society (relevant for policy makers);***

co-benefits **can have a significant value but most often they are disregarded being the reason for the underestimation of the full value of the renovation works**

IEA EBC Annex 56 | Co-Benefits

	CO-BENEFITS	Thermal Comfort	Natural Lighting	Air Quality	Building Physics	Internal Noise	External Noise	Ease of Use / Control by User	Reduced Exposure to Energy Price Fluctuations	Aesthetics	Useful Living Area	Pride / Prestige	Ease of Installation / Reduced Annoyance
Ref. Pack.	Replacement of heating system												
	Replacement of DHW system												
Renovation Package 1	Insulation of entire building envelope	P			P					P	P		P
	Internal shading	P	N					N				N	
	Replacement of heating system	P						P	P				
	Replacement of DHW system								P				
Renovation Package 2	Windows replacement	P											
	Insulation of entire building envelope	P			P				P	P		P	
	Internal shading	P	N					N				N	
	Replacement of heating system	P						P					
	Replacement of DHW system								P				
Chosen Renovation	Windows replacement	P											
	Insulation of roof	P			P				P				
	Insulation of facades	P			P				P	P		P	
	Internal shading	P	N					N				N	
	Replacement of heating system	P						P					
	Replacement of DHW system								P				

Legend: P - Positive Effect; N - Negative Effect

- The integration of co-benefits into the decision making process is difficult

- These benefits are often difficult and almost impossible to quantify and measure making it very difficult to add their contribution into a traditional cost-benefit analysis

- Through the case-studies a matrix has been developed in order to correlate the renovation measures with the Positive or Negative impacts

IEA EBC Annex 56 | Calculations on Generic Buildings

Inputs from 8 European countries (AT, CH, DK, ES, IT, NO, PT, SE)

To develop and support the methodology:

- **Generic buildings with the prevailing typologies and constructive solutions in each country have been selected**
- **Parametric studies were performed on them**
- **Validation with real case-studies from 6 countries (AT, DK, ES, IT, PT, SE)**

IEA EBC Annex 56 | Case Studies

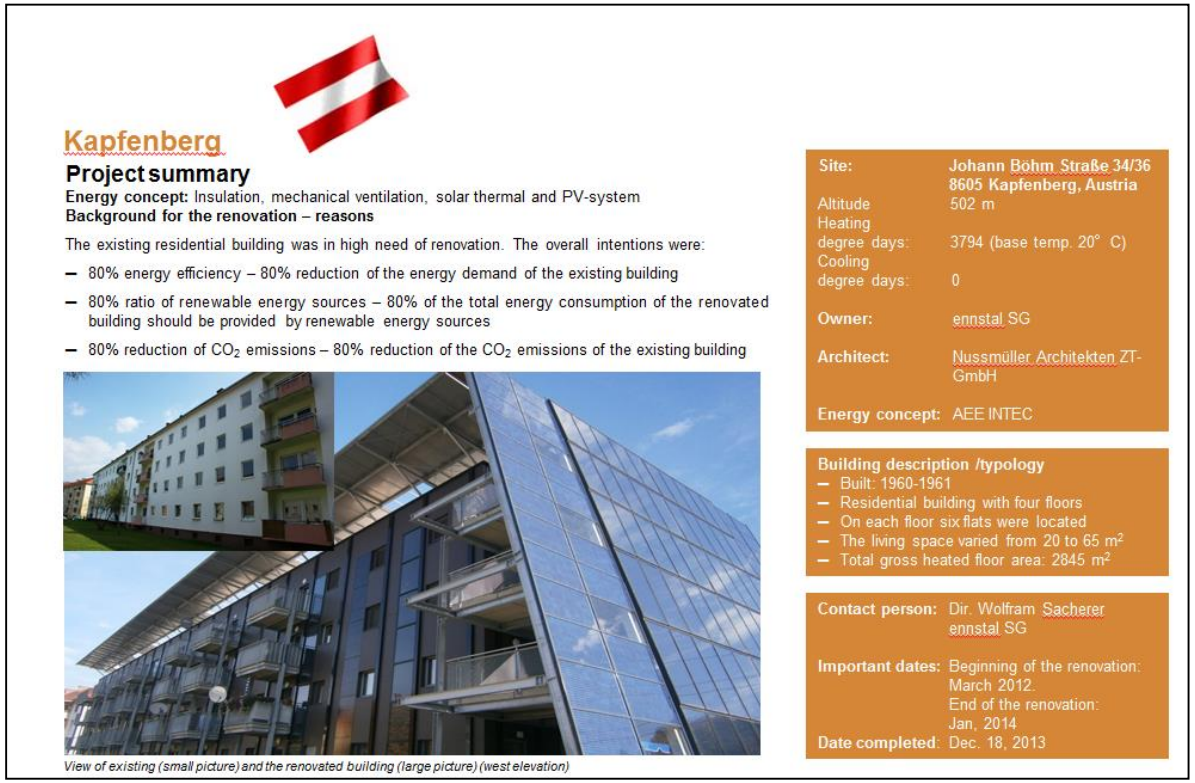
“Shining Examples” - success stories used for motivation and stimulation purposes

“Detailed Case Studies” – used to test the impact and relevance of different renovation measures and strategies and to test the developed methodology

IEA EBC Annex 56 | Shining Examples - Content

Shining Examples Brochure published in May 2014 – 9 Case-Studies from 6 countries

Shining Examples Brochure to be published in June 2015 – 18 Case-Studies from 9 countries



Kapfenberg

Project summary

Energy concept: Insulation, mechanical ventilation, solar thermal and PV-system

Background for the renovation – reasons

The existing residential building was in high need of renovation. The overall intentions were:

- 80% energy efficiency – 80% reduction of the energy demand of the existing building
- 80% ratio of renewable energy sources – 80% of the total energy consumption of the renovated building should be provided by renewable energy sources
- 80% reduction of CO_2 emissions – 80% reduction of the CO_2 emissions of the existing building

Site:	Johann Böhm Straße 34/36 8605 Kapfenberg, Austria
Altitude	502 m
Heating degree days:	3794 (base temp. 20° C)
Cooling degree days:	0
Owner:	ennstal SG
Architect:	Nussmüller Architekten ZT-GmbH
Energy concept:	AEE INTEC

Building description /typology

- Built: 1960-1961
- Residential building with four floors
- On each floor six flats were located
- The living space varied from 20 to 65 m^2
- Total gross heated floor area: 2845 m^2

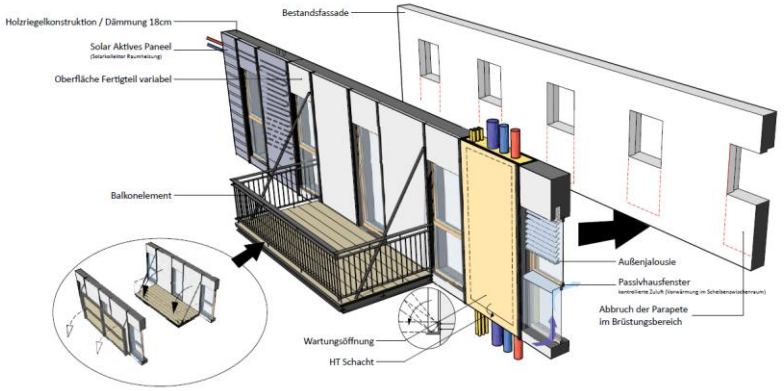
Contact person:	Dir. Wolfram Sacherer ennstal SG
Important dates:	Beginning of the renovation: March 2012. End of the renovation: Jan. 2014
Date completed:	Dec. 18, 2013

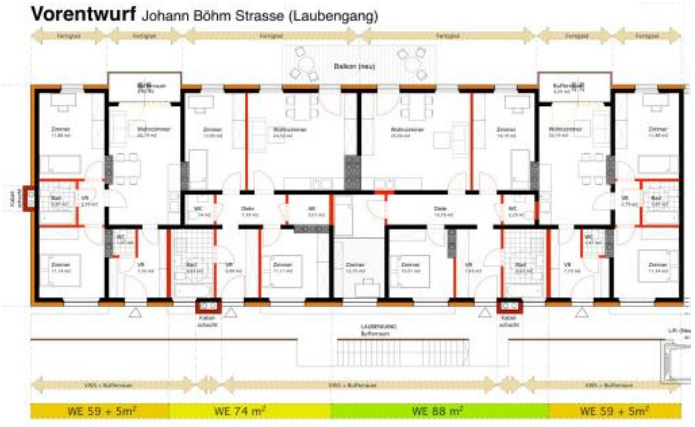
View of existing (small picture) and the renovated building (large picture) (west elevation)

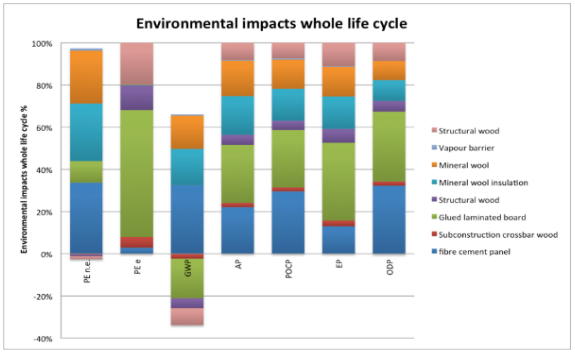
- **Project summary**
  - **Energy concept: Insulation, mechanical ventilation, solar thermal and PV-system**
  - **Background for the renovation – reasons**
- **Building envelope, heating, ventilation, cooling and lighting systems before and after the energy renovation**
- **Energy renovation features**
- **Calculated Energy Savings, CO_2 reductions and Life Cycle Costs**
- **Overall improvements**
- **Summary and Lessons Learnt**

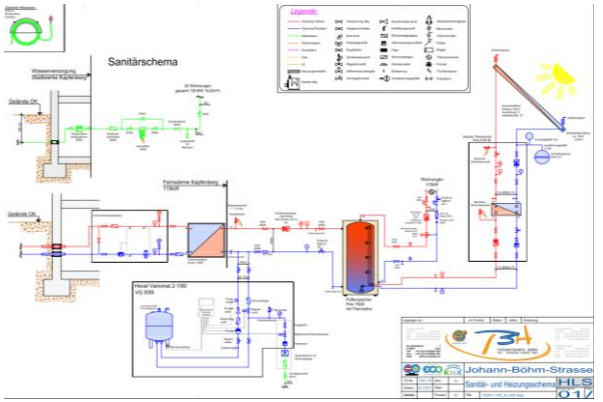
IEA EBC Annex 56 | Detailed Case Studies - Content

- Renovation concept and strategy
- Renovation design details (building envelope, building services)
- Integrated building performance (environmental, economical, socio cultural and technical sustainability)
- Performance Indicators
- Improvements and co-benefits
- Comparison of different renovation packages

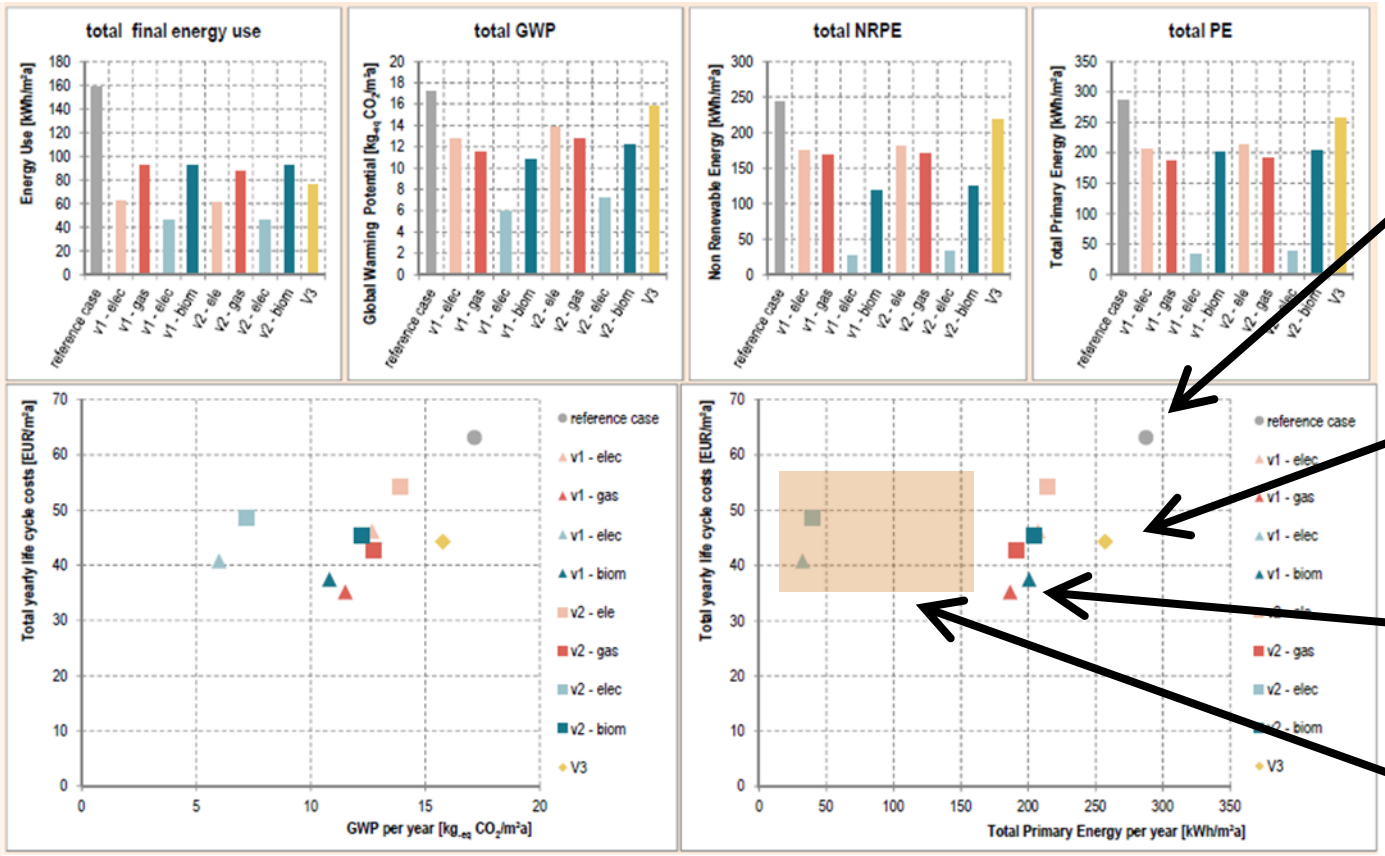








IEA EBC Annex 56 | Detailed Case Studies



Reference scenario
(renovation scenario without improving energy performance)

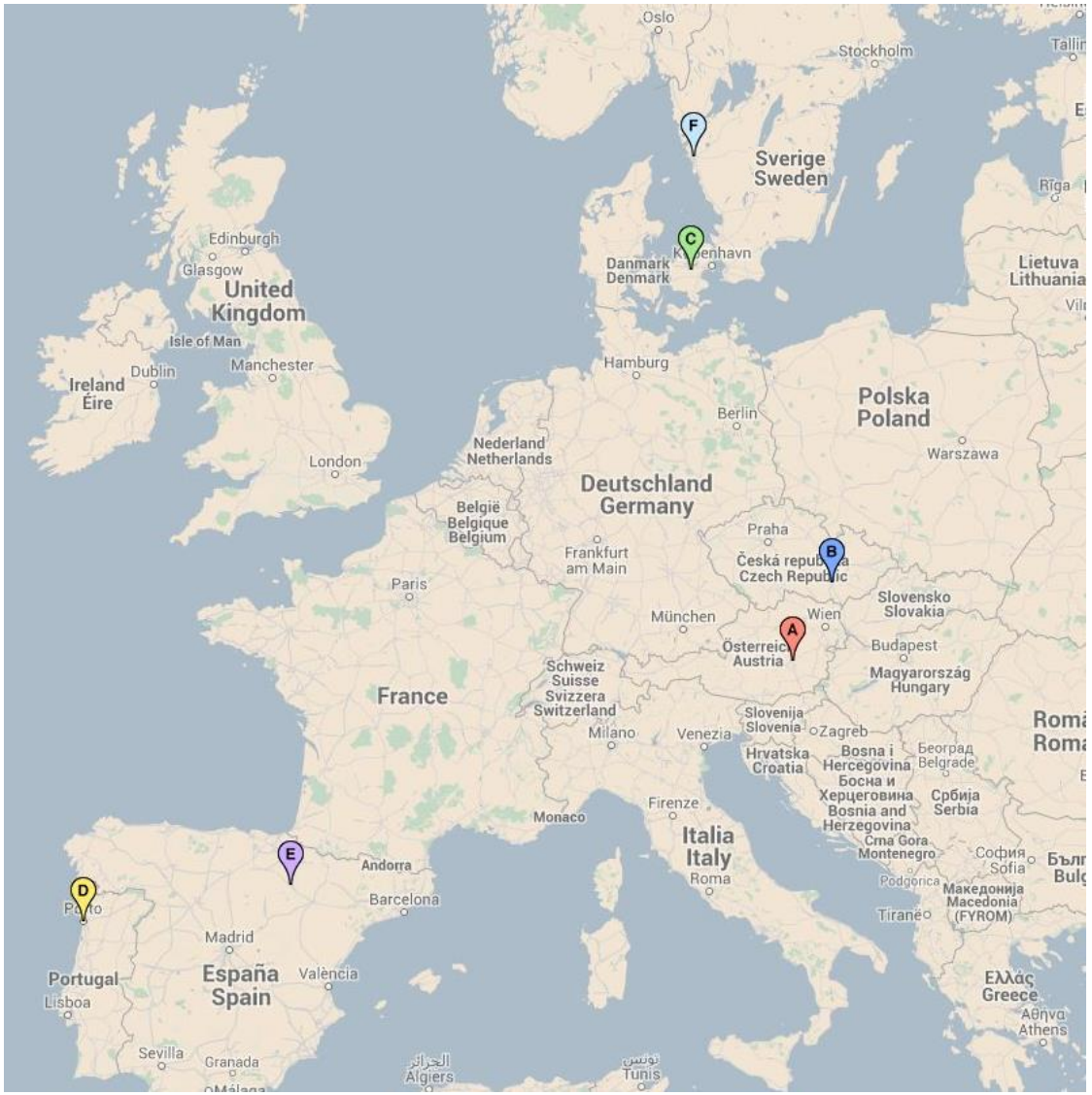
Real scenario
(renovation scenario that has been implemented)

Cost optimal scenario

Renovation scenarios beyond cost optimal

Analyzing real building renovation projects and comparing with alternative scenarios

Overview of Detailed Case Studies



A 

Austria – multi-family building

B 

Czech Republic – elementary school

C 

Denmark – multi-family building

D 

Portugal – two-family building

E 

Spain – multi-family building

F 

Sweden – multi-family building

IEA EBC Annex 56 | General conclusions

- The cost optimal level does not lead to zero (or nearly zero) energy or emissions levels. It is essential to go a step further and explore the full potential of the cost-effective energy related renovation measures
- The optimal renovation scenario for the envelope hardly depends on the type of heating system
- The improvement of the energy performance of buildings' envelope within the building renovation process is essential to assure comfort and prevent pathologies
- It is important to act on as many envelope elements as possible. The number of building elements renovated is more important than the energy efficiency level of a single building element

IEA EBC Annex 56 | Draft Conclusions for standard setting and policy making

Based on these kind of conclusions we are developing the Guidebook with some recommendations specially targeted to Policy Makers and Professional Owners

Recommendation: Synergies between renewable energy measures and energy efficiency measures must be encouraged

For building owners: The replacement of the heating system is an excellent opportunity to carry out renovation measures on the building envelope as well, creating synergies. If carried out together, the investments in the building envelope result in savings on the investment costs for the heating system, because the more energy efficient a building is, the smaller can be the dimension of the heating system

For policy makers: It is recommendable that standards and other policy measures, for example subsidies, create incentives to combine renovation measures on the building envelope with a replacement of the heating system, in order to make sure that reductions in energy use and emissions are achieved most efficiently

For Technicians and Professional Owners we have adapted the Danish tool ASCOT

ASCOT

The results of the calculations are listed below

		REFERENCE BUILDING		ENERGY OPTIMAIZED	
Space heating		165,0		143,1	
Domestic hot water		16,8		16,8	
Solar heat		0,0		0,0	
Net heating		181,8		160,0	
Losses from installations		0,0		0,0	
Total needs of heating	**kWh/m² year**		**181,8**		**160,0**
Electricity to heat pump		0,00		0,00	
Pumps		2,85		2,47	
Fans		3,48		3,16	
PV production		0,00		0,00	
Net demand	**kWh/m²**	**6,33**		**5,64**	
Net demand x 2.5	**kWh/m² year**		**15,8**		**14,1**
Cooling	**kWh/m² year**	**0,7**	**0,7**	**0,8**	**0,8**
Energy consumption	**kWh/m² year**		**198,3**		**174,8**
Energy requrement	kWh/m² year		88,9		88,9
Low energy class 2	kWh/m² year		66,6		66,6
Low energy class 1	kWh/m² year		38,6		38,6
RUNNING COSTS PER UNIT					
Heat	Eu /year		1421		1290
Pump+fans	Eu /year		189		169
PV production	Eu /year		0,0		0
TOTAL RUNNING COSTS	Eu /year		1.611		1.459

cations of the reference building. All orange figures can be modified.

IG DATA

ng type	One family house	
ed floor area per dwellengs	116,7	m²
er of dwellings	1	
er of floor level	1	
height	3	m
etri grundplan	2	
d basement	0%	
w arealtreated floor area	22%	
bution of window area	south 15%	west 40% north 15% east ##

WEATHER DATA

Copenhagen COP

CURRENCY

DKK/curre 0,133

Basement temp. 10 oC

HEATING LOCATION

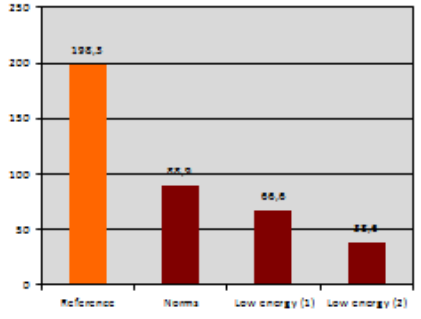
cation from south	20 grader (90 = lodret)
	0 grader (0 = syd)

VOLTAIC LOCATION

cation from south	20 grader (90 = lodret)
	0 grader

ILD/RENOVATION	New Build
TION LEVEL	Isolation
TYPE OF CONSTRUCTION	Medium heavy
VINDOVS	3-layer energy glass
HEAT SUPPLY	District heating
TYPE OF VENTILATION	MVHR good system efficiency
HEATING SYSTEM	Radiators
HOT WATER CONSUMPTION	Standard consumption

Yearly energy consumption, kWh/m²



IEA EBC Annex 56 | Information

Website is online www.iea-annex56.org

IEA EBC Annex 56 | Available Reports

Newsletters

Newsletter #5
March 2015

EBC Annex 56

MEETINGS

Alicante Meeting

The 6th meeting of the working phase of Annex 56 took place in Alicante, Spain, on March 10th, 11th and 12th 2014.

The 20 participants from 9 countries, were updated about the developments of the subtasks, in particularly the first deliverables of subtask A — methodology, generic calculations, LCIA and co-benefits, and subtask C — Case studies. Those deliverables (methodology report, and shining examples brochure) were concluded and send to the IEA ExCO reviewers for final revision and approval.

The Methodology Report is a very important document to be used by the European Commission in the context of preparing the EU Member States National Renovation Plans.

There was also the opportunity to visit a energy renovated neighbourhood, in the outskirts of Alicante.

EBC graphic guidelines

In the current year, and following the change from ECBCS to EBC, there was the need to redesign all the graphic contents regarding EBC projects, where Annex 56 is included.

In further consequence all produced outcomes have to follow those guidelines, including the website, newsletters, reports and all written information.

This is the first newsletter reflecting those changes, whilst the project website and documents were already changed.

Brno Meeting

On the 15th, 16th and 17th September 2014, the 7th meeting of the working phase of Annex 56 took place in Brno, Czech Republic, and counted 25 participants, some of which were new in the project.

A status of the project was made, focusing on the upcoming deliverables of the different subtasks, and the necessary developments to achieve those outcomes, in particular the Renovation Guidebook. The methodology report and the shining example brochure were approved by the IEA ExCO, making these documents the first deliverables to be finished. Both documents are available for download on the project's website.

A set of reports regarding different work packages conclusions are being prepared and will allow to have a deeper understanding of the results achieved in the project. As usual in these meetings a technical visit on energy renovated buildings took place, focusing particularly a school and a residential building in Brno-Nový Lískovec.

On the 2nd day of the meeting, a workshop was held together with the municipality of Brno-Nový Lískovec, where some examples of refurbished buildings were presented, as well as the project's goals and objectives.

www.iea-annex56.org

EBC Annex 56

Shining examples brochure

In Annex 56, the gathering of case studies is one of the activities undertaken to reach the overall project objectives because it is a recognized fact that the process of decision-making has to be strongly supported by success stories from real life and experiences and lessons learned from practice.

The specific mission of the case study activity of the Annex 56 project is to provide significant feedback from practice (realised, ongoing or intended renovation projects) on a scientific basis. The main objectives of this work are:

- To understand barriers and constraints for high performance renovations by a thorough analysis of the case studies and feedback from practice in order to identify and show measures to overcome them;
- To align the methodology under development in Annex 56 with practical experiences;
- To support decision-makers and experts with profound, scientific based information (as result of thoroughly analysed case-studies) for their future decisions;
- To show successful renovation projects in order to motivate decision-makers and stimulate the market.

The brochure presents the Shining Examples collected in a fixed format showing for each demonstration project pictures and easily comprehensible graphics, highlighting the added value of the renovation process. The brochure presents 9 Shining Examples from 6 countries. The gathering of shining examples continues through the entire lifetime of Annex 56 and all examples will be presented in a final document at the end of the project. At the end of the project is expected to have 18 Shining Examples from 9 countries.

The "Shining Examples" are gathered mainly for motivation and stimulation purposes, highlighting the advantages of the energy and carbon emissions cost optimized renovation. The focus is to highlight advantages and innovative (but feasible) solutions and strategies. A cross-section analysis of the projects has also been carried out to identify similarities, differences and general findings. The results of this analysis are presented in 5 sections covering: barriers/solutions, anyway measures, rational use of energy/renewable energy supply (RUE/RES) balance of measures, co-benefits and country/climate specific measures.

As mentioned before, the shining example brochure as well as each individual example, are available for download:

http://iea-annex56.org/Index.aspx?MenuID=4&SubMenuID=17

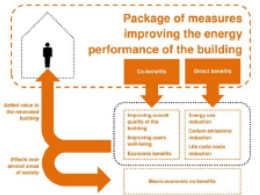
Each partner was asked to provide additional case studies, in order to increase the range of building renovations compiled in the brochure.

Co-benefits

Some preliminary results regarding co-benefits identified in a building renovated in Oporto, Portugal were presented in the meeting, and allowed to have a better understanding of the additional benefits (apart from energy and CO_2 emissions) perceived by the tenants, when a building is renovated.

The evaluation of building renovation measures normally considers only the energy savings and the costs, disregarding other relevant benefits and thus, significantly underestimating the full value of improvement and re-use of buildings. These benefits can be felt at the building level (like increased user comfort, fewer problems with building physics, improved aesthetics), but also at the society level (like health benefits, job creation, energy security, impact on climate change).

It is a main goal of Annex 56 to give guidance to building owners and promoters to integrate co-benefits in their cost/benefit assessment and subsequent decision making for energy related building renovation and to policy makers to highlight the relevance of considering the broader impact of energy policies in several other areas of policy making.



Direct benefits and co-benefits from cost effective energy and carbon emissions related building renovation

www.iea-annex56.org

EBC Annex 56

BUILDING RENOVATION EXAMPLES

On each meeting it is common to have a site visit, where some examples of refurbished buildings are shown to the participants.

This allows to have a wider understanding towards building renovation, because it is possible to see different strategies and approaches, depending on the country / city that hosts the meeting. This particular newsletter compiles two site visits, the one that took place in Alicante, Spain as well as Brno, Czech Republic.

Additional and detailed information about those examples are available in the following pages.

ALICANTE, SPAIN

Site:	San Juan XXIII neighborhood Alicante, Spai
Altitude:	83 m
Heating degree days:	856 (base ten
Owner:	Municipality o
Architect:	IVE—Instituto Edificación
Energy concept:	IVE—Instituto Edificación

Project summary

- San Juan XXIII is a social housing neighbourhood located in Alicante, a city in eastern Spain, which has a south Mediterranean climate: mild temperatures in winter and very hot summers.
- The neighbourhood has high social problems and several signs of decay. There are high proportions of low-income people and a high proportion of immigrant population. Moreover, it is disconnected from the rest of the city, in an area of difficult access.
- The case study involves 324 dwellings built in 1967. It was built in order to respond to a high demand in housing.
- The neighbourhood typology are low-rise isolated buildings with low quality.

www.iea-annex56.org

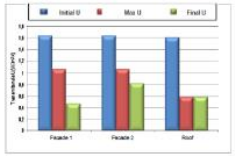
EBC Annex 56

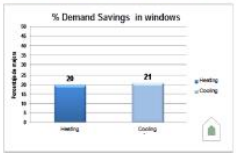
Description of building

The main goal of the project was the renovation of facades and roofs to improve the quality, comfort and energy efficiency of buildings.

The study developed by IVE was to provide an environmental assessment of the buildings in their current state and in their final state, after the energy efficiency improvements. The study considered different options for saving energy in terms of making the project as cost-effective as possible.

Element	U-Value before renovation W/m²K	U-Value after renovation W/m²K
Façade	1.64	0.47—0.83
Roof	1.61	0.59
Windows	5.70	3.54

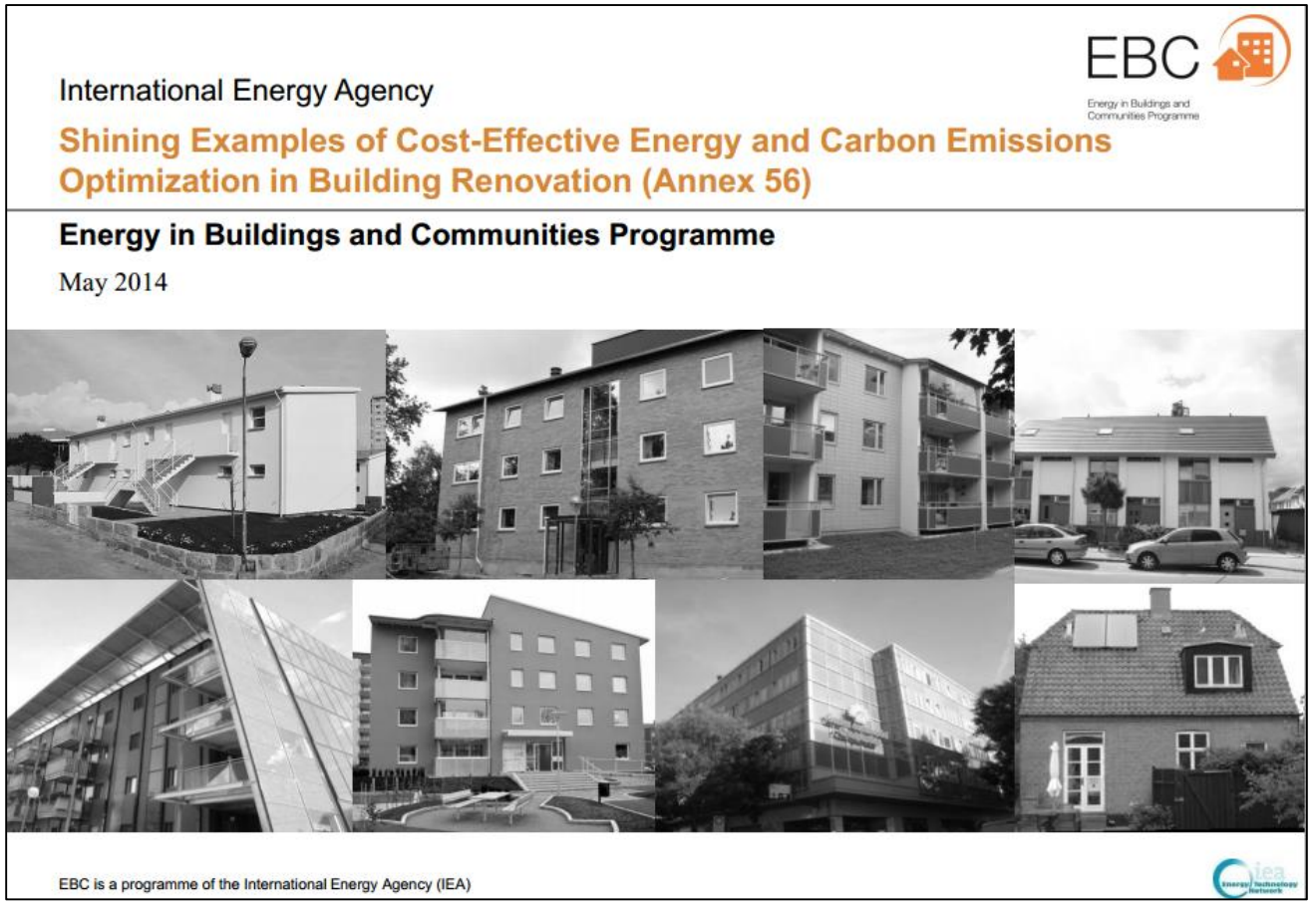




www.iea-annex56.org

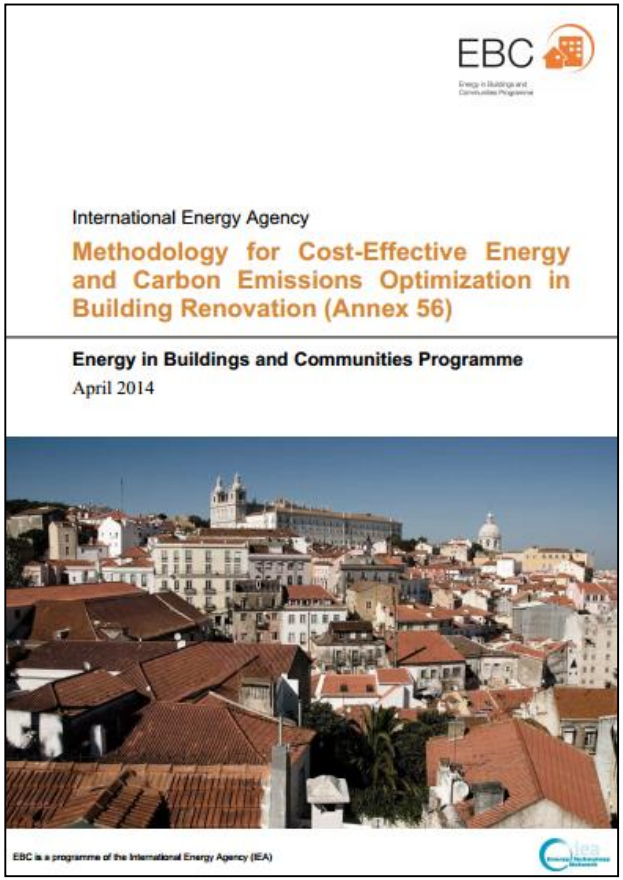
IEA EBC Annex 56 | Available Reports

Shining Examples Brochure



IEA EBC Annex 56 | Available Reports

Methodology Report



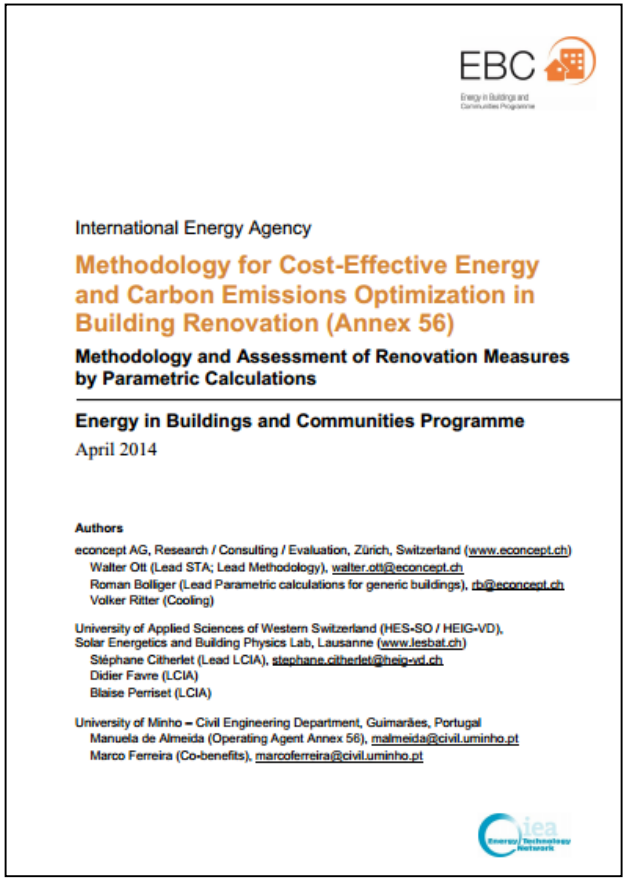
International Energy Agency

Methodology for Cost-Effective Energy and Carbon Emissions Optimization in Building Renovation (Annex 56)

Energy in Buildings and Communities Programme

April 2014

EBC is a programme of the International Energy Agency (IEA)



International Energy Agency

Methodology for Cost-Effective Energy and Carbon Emissions Optimization in Building Renovation (Annex 56)

Methodology and Assessment of Renovation Measures by Parametric Calculations

Energy in Buildings and Communities Programme

April 2014

Authors

econcept AG, Research / Consulting / Evaluation, Zürich, Switzerland (www.econcept.ch)
Walter Ott (Lead STA; Lead Methodology), walter.ott@econcept.ch
Roman Bolliger (Lead Parametric calculations for generic buildings), rb@econcept.ch
Volker Ritter (Cooling)

University of Applied Sciences of Western Switzerland (HES-SO / HEIG-VD), Solar Energetics and Building Physics Lab, Lausanne (www.lesbat.ch)
Stéphane Citherlet (Lead LCIA), stephane.citherlet@heig-vd.ch
Didier Favre (LCIA)
Blaise Perriset (LCIA)

University of Minho – Civil Engineering Department, Guimarães, Portugal
Manuela de Almeida (Operating Agent Annex 56), malmeida@civil.uminho.pt
Marco Ferreira (Co-benefits), marcoferreira@civil.uminho.pt

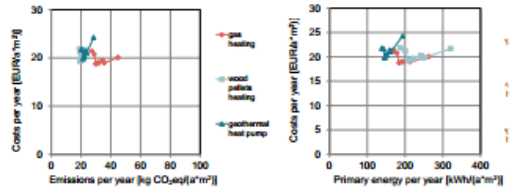


Figure 71 Aggregated comparison of cost effectiveness of energy efficiency renovation measures for different heating systems and related impacts on carbon emissions and primary energy use in **Spain, for multi-family building.** The reference case is the point on the natural gas heating curve with the highest emissions/primary energy use, as no measures are carried out to improve the energy performance in that case.

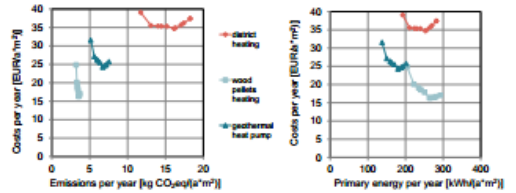


Figure 72 Aggregated comparison of cost effectiveness of energy efficiency renovation measures for different heating systems and related impacts on carbon emissions and primary energy use in **Sweden, for single-family building.** The reference case is the point on the district heating curve with the highest emissions/primary energy use, as no measures are carried out to improve the energy performance in that case.

146

IEA EBC Annex 56 | Reports available in 2016

- Methodology for Cost Effective Energy and Carbon Emissions Optimization in Building Renovation
- Report on parametric calculations for the assessment of the impacts of energy related building renovation measures
- Report on Integration of LCIA into the Assessment of Renovation Measures
- Report on Co-Benefits of Building Renovation
- Report on the tools used
- Brochure "Shining Examples“
- Report on "Detailed Case Studies“
- Report on User Acceptance
- Renovation Guidebook

Thank you

COST EFFECTIVE ENERGY AND CARBON EMISSIONS OPTIMIZATION IN BUILDING RENOVATION

Manuela Almeida

malmeida@civil.uminho.pt

University of Minho, Civil Engineering Department

Guimarães, Portugal