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Energy Conservation in Buildings and Community Systems Programme

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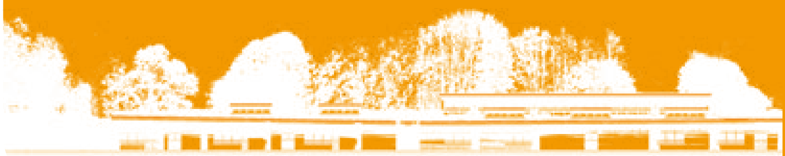

Austria Hosts Major Workshop for Energy Conservation and Solar Heating and Cooling in Buildings and Communities

Zero Energy Houses in Weiz

Werner Weiss, ECBCS Executive Committee Member for Austria

In the framework of the joint Executive Committee Meetings of the ECBCS programme and the Solar Heating and Cooling programme in June 2008, Austria hosted an accompanying technical day. Most of the projects visited in the region of Styria are the results of the Austrian research and demonstration programmes “House of the Future” and “Energy Systems for the Future” (for details see: www.nachhaltigwirtschaften.at).

In these programmes, the Austrian Ministry for Transport, Innovation and Technology spent 55 Million Euros in order to support R&D as well as the demonstration of advanced solar energy and energy efficient building technologies.

Delegates visited a large-scale solar heating system at a multi-family house with 58 apartments, and a solar district heating system with an installed capacity of 985 kWh (1,407 m^2 flat plate collectors) in the city of Graz, as well as to an Old People’s Home, which was renovated to a high standard with passive house building components, and to a Zero Energy housing estate.

The Old People’s Home in the city of Weiz was constructed in 1973. Since neither the building’s heat demand nor its indoor climate met today’s standards, it was retrofitted in the year 2006.

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Energy Efficient Communities

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With sufficient insulation and new windows integrated into a new prefabricated façade system, and the installation of an air ventilation system with heat recovery, the heat demand was reduced from 157 kWh/m²a to 24 kWh/m²a. This shows that it is possible to reduce the heat demand by more than 80%, at the same time significantly improving the indoor climate and air quality.

The heat supply is now provided by district heating and the newly installed solar thermal plant of 160 m² (112 kWth).

The second project, located in Weiz, is the Zero Energy housing estate “PlusEnergieWohnen”. The idea behind the project was to create a passive house settlement, which parallels the purchase price of conventional houses.

The entire terraced housing estate consists of 22 units. The heat demand is 13.5 kWh/m².a due to the passive house standard. 4-5 kWpeak photovoltaic systems are installed on each of the terraced houses. The electricity produced is fed into the public grid.

The heat for hot water and space heating is provided by a heat pump. This results in a surplus of 1,000 kWh on an annual balance between the electricity demand of the building and the production of the PV system. With a result such as this these houses can be considered “Net-Zero-Energy Buildings”.

Fig.1: Old People’s Home before and after its renovation

Fig.3: Energy balance of the buildings

FREE DOWNLOADS

Over 60 reports from ECBCS projects are available to download free of charge from the website - www.ecbcs.org

Towards Net Zero Energy Solar Buildings (NZEBs) – Joint Project with Solar Heating and Cooling Approved

Mark Riley, ECBCS Annex 52

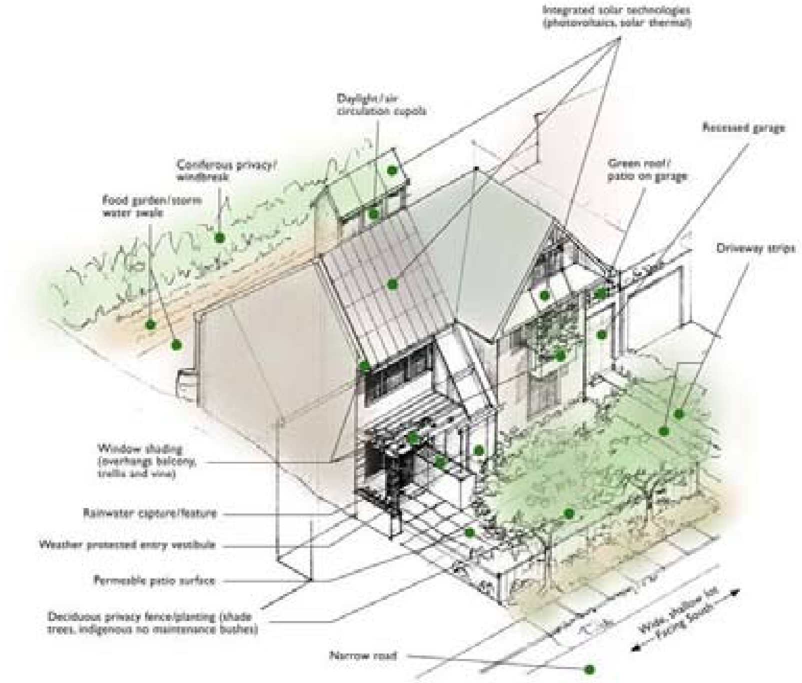


Figure 1: Equilibrium Net-Zero-Energy Healthy Housing Concept (www.cmhc.ca/en/inpr/su/eqho)

Background

Energy use in buildings worldwide accounts for over 40% of primary energy use and 24% of greenhouse gas emissions[1]. Energy use and emissions include both direct, on-site use of fossil fuels as well as indirect use from electricity[2], district heating/cooling systems and embodied energy in construction materials.

Given the global challenges related to climate change and resource shortages, much more is required than incremental increases in energy efficiency. Currently, a prominent vision proposes so called “net zero energy”, “net zero carbon” or “EQuilibrium” buildings[3] (Figure 1). Although these terms have different meanings and are not well understood, several IEA countries have adopted this vision as a long-term goal of their building energy policies[4]. What is missing is a clear definition and international agreement on the measures of building performance that could inform “zero energy” building policies, programs and industry adoption around the world.

What is known about achieving “zero” in buildings?

The first strategy is to reduce energy demand through suitable architectural design and improved building envelopes. Measures for achieving this depend on climate and building type and include insulation, improved glazings and daylighting, airtight building envelopes and natural ventilation as well as active or passive shading for control of solar gains. Improving the efficiency of energy systems and services through better heating, cooling and ventilation systems, controls and lighting is the corresponding strategy for efficient use of the energy supplied. The so-called “Passive House” reflects these concepts for cold and moderate climates.

However, to reach “zero” use of fossil fuels or zero-carbon emissions requires intensive utilization of renewable energy concepts including solar heating, solar cooling, solar PV, biofuels or other clean energy generation sources.

The “net zero” option

Zero energy buildings (ZEBs) are not a new concept (Figure 2). An area of focus has been autonomous building energy options. With existing technology, this “off-grid”

Figure 2: The Energy Autonomous House, Freiburg 1991

approach has been and still is a technical, economical and ecological challenge for most applications[5]. For example, seasonal and daily variations of demand and supply, at most locations worldwide, result in costly over-sizing of energy supply systems. In addition, autonomous buildings require expensive thermal storage systems that can embody large amounts of energy relative to the small energy stored and designing efficient, long-term electrical storage is a problem still to be solved. Furthermore, most of these so-called ZEBs do require some “imported” energy for backup and high power density loads, such as cooking.

Addressing the limitations of autonomous buildings, while still achieving “zero”, leads to utility-connected solutions that optimize energy generation, distribution and storage. This “net zero” approach (NZEBs) still incorporates on-site renewable energy but the focus is on achieving an annual balance of energy supply and demand economically through interactions with electricity grids and other utilities such as community energy systems[6].

To minimize impacts to grids by reducing the mismatch of supply and demand, the NZEB approach requires a very high level of energy-efficiency, smart controls, load management and on-site solar energy utilization[7] (Figure 3). This approach applies to the existing building stock as well as to new buildings, clusters of buildings and small settlements.

Objective and Scope

The objective of this project, which is a joint activity with the IEA Solar Heating & Cooling (SHC) Programme, is to study current net-zero, near net-zero and very low energy buildings and to develop a common understanding, a methodology, tools, innovative solutions and industry guidelines. A primary means of achieving this objective is to document and propose practical NZEB demonstration projects, with convincing architectural quality. These exemplars and the supporting sourcebook, guidelines and tools are viewed as keys to industry adoption. These projects will aim to equalize their small annual energy needs, cost-effectively, through building integrated heating/cooling systems, power generation and interactions with utilities.

The planned outcome is to support the conversion of the NZEB concept from an idea into practical reality in the marketplace. The project’s source book and the datasets will provide realistic case studies of how NZEBs can be achieved. Demonstrating and documenting real projects will also lower industry resistance to the adoption of these concepts.

To achieve these objectives the project is organised around the following research areas:

1) Definitions & Large-Scale Implications

The objective here is to establish an internationally agreed understanding on NZEBs based on a common methodology.

2) Design Tools and Simulation

This area aims to identify and refine a suite of design tools to support industry adoption of NZEBs.

3) Advanced Building Design, Engineering and Technologies

The objectives here are: to develop and test innovative, whole building net-zero solution sets for cold, moderate and hot climates with exemplary architecture and technologies that would be the basis for demonstration projects and international collaboration.

4) Dissemination

The objective of the dissemination activity is to support knowledge transfer and market adoption of NZEBs on a national and international level.

Expected Results

The products of this project are targeted to the building industry (building manufacturers, manufacturers of components and systems), housing companies and building developers, architects, building engineers and utilities.

Expected results of the activity will consist of:

Area 1:

(a) Harmonized international definitions framework and a monitoring, verification and compliance guide.

(b) A report on the technical potential including impacts on grids.

Area 2:

(a) Identification of a suite of NZEB tools to support the design process and user manuals.

(b) With SHC, worked examples and case studies to support industry adoption.

Area 3:

(a) Case studies, demonstration projects and knowledge for the task sourcebook and database and other dissemination materials.

(b) Solution sets for different climates and building types incorporating market available and near market technologies and systems and integrated concepts for industry adoption.

Area 4:

(a) An NZEB web page and database.

(b) An NZEB source book covering the methodology, technologies, tools, case studies and demonstration projects.

(c) Education network for students, summer school and contributions to the Solar Decathlon and similar student activities.

(d) Technical papers, special issues of industry magazines, brochures and booklets.

Time Schedule

This project started on October 1, 2008 and will remain in force until September 30, 2013. A “start-up“ phase will be conducted from October 1st, 2008 to April 30th, 2009. This “start-up“ phase will focus on preparation of the detailed workplans for each research area and provide time to establish national teams and secure funding for participation in the work. Work will also begin on NZEB definitions under research area 1 and background information will be gathered. The “start-up“ phase shall be followed by a 4-year "work" phase to June 30th, 2013 and then a 3 month “wrap-up“ phase ending September 30th, 2013.

Operating Agent

The Operating Agent will be the Building and Communities Group of CANMETEnergy of Natural Resources Canada, represented by Mark Riley[8].

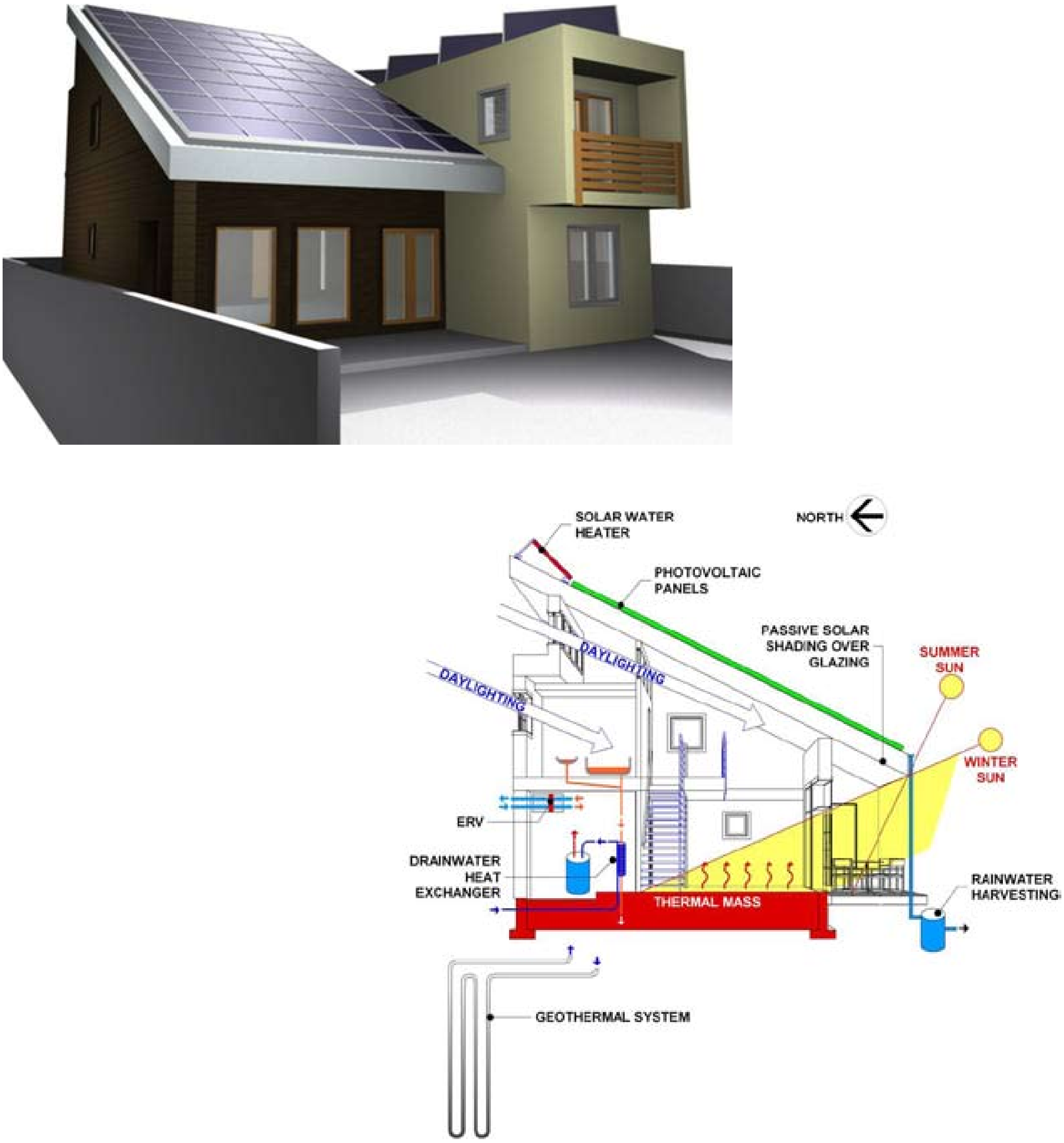


Figure 3: Tsuchiya Twoby Net-Zero-Energy Home, Sapporo, Japan

The Future for Sustainable Built Environments: Integrating the Low Exergy Approach

Conference Announcement

April 21st 2009

To be held at Cultuurcluster "Gen Coel" , Groeet Genhei 20, 6413 Heerlen (The Netherlands)

This conference about the future of sustainable built environments will focus on providing front-edge results in the field of exergy analysis of buildings and communities.

Additionally, a platform is created to exchange and discuss further information among participants.

More information: *www.annex49.com*

Organisers/Hosts of the conference:

1. Fraunhofer Institute for Building Physics, Kassel (Germany)

   www.ibp.fraunhofer.de

2. CAUBERG-HUYGEN Raadgevende Ingenieurs BV, Maastricht (The Netherlands)

   www.chri.nl

3. SenterNovem, Sittard (The Netherlands)

   www.senternovem.nl/senternovem

4. Technische Universiteit Delft (The Netherlands)

   www.tudelft.nl

Energy Efficient Communities – A New Project to Help Urban Decision Makers Meet Energy Targets

Reinhard Jank, ECBCS Annex 51

The ECBCS Executive Committee approved a new project on Energy Efficient Communities. Reinhard Jank from Volkswohnung GmbH, a German housing company, was asked to prepare the new project in co-operation with interested countries.

An 'experts' meeting' took place in April 2008 in Eindhoven, Netherlands, This meeting showed that public programs on energy politics in communities have either been established recently, as in The Netherlands, Japan and Germany, or are in their preparation phase, as in Canada and France. As a result, all countries attending the meeting in Eindhoven were very interested in joining an ECBCS-project on this topic. Concerning the involvement of communities, it was concluded at the experts meeting, that a strong increase of interest in sustainability issues is currently apparent in community administrations as a result of pressure from both national and urban politics. As a result, ambitious targets are often set by communities – such as, for example, a decrease of CO_2-emissions by 50 % within the next 20 years – but with limited understanding of the consequences. According to the experts, the difficulties in achieving such targets are not caused by a lack of technology, but by:

- Insufficient know-how on strategic planning,
- Insufficient management ability during the implementation process, and
- Insufficient availability of tools and instruments for decision making, planning and monitoring.

The project's work plan should reflect this situation and - as its main objective - provide a practical guide for urban decision makers on how to achieve ambitious energy and CO_2-targets on a local and urban scale.

A second experts' workshop was organized in September 2008 in Juelich, Germany.

Description

The title of the new Annex is:

Energy Efficient Communities: Case Studies and Strategic Guidance for Urban Decision Makers

The work plan of the project will address small units such as neighborhoods or quarters, and towns or cities as well. The purpose is to provide urban administrations, urban planners and other urban stakeholders with the necessary knowledge and means to be able to define reasonable goals in terms of energy efficiency, energy conservation and GHG abatement on the level of communities, as defined above. As a result, the project's focus is on a planning approach and implementation strategies enabling stakeholders within communities to establish a successful local energy or climate change policy.

The project will have four tasks.:

A: Organizational Models, Implementation Instruments and Planning Tools for Local Administrations and Developers – a State-of-the-Art Review

Work Plan:

(1) Gather successful examples of community energy planning projects.

(2) Review data acquisition methods and monitoring tools for municipal energy and GHG balances

(3) Review state-of-the-art urban or local energy system modelling and simulation tools and their combination with conventional planning tools.

(4) Describe legal framework for urban energy and climate change policies.

(5) Compare and evaluate approaches in participating countries

(6) Evaluate building related sustainability assessments.

B: Case Studies on Energy Planning and Implementation Strategies for Neighbourhoods, Quarters and Municipal Areas

The case studies will contain either:-

(1) integrated long-term concepts for energy efficient neighbourhoods, city blocks or quarters by refurbishment of the existing building stock, supply of "LowEx" energy such as waste heat, use of local renewable energy sources and the strategies necessary for successful implementation

or:-

(2) planning and development of new "green" settlements.

For the building stock involved in case (1), the objectives are to be met by a combination of retrofit measures to reduce energy demand with an optimized exergetic energy supply and/or the use of renewables. In case (2), due to a greater degree of freedom for the planner, a "holistic" optimization of the whole system is planned. The whole set of issues, from technical/economic optimization and supply security, user acceptance/marketing to urban sustainable development, are to be covered by the selected case studies.

C: Case Studies on the Preparation of Integrated Energy and CO_2-Abatement Concepts for Towns or Cities and Implementation Strategies

The work plan of these case study evaluations will contain:

- Methods to analyze the existing state

of the urban energy system and its performance

- Appropriate and cost-efficient data acquisition methods on an urban level
- Application of suitable methods and planning tools to develop a comprehensive energy master plan (planning support for local decision makers)
- The development of communication and learning processes for local stakeholders / decision makers
- Examples to elaborate an implementation strategy
- Selection and use of an urban-wide monitoring system.

D: Instruments for a Successful Community Energy Policy

Work Plan:

(1) Guidebook to Successful Urban Energy Planning

The main purpose is to elaborate the means that are necessary to enable the project's target group (decision makers in urban administrations, developers, urban planners) to establish and implement a successful local or urban energy strategy. The Annex 51 product which is most important in this context will be the "Guidebook to Successful Urban Energy Planning".

(2) Community Energy Concept Adviser

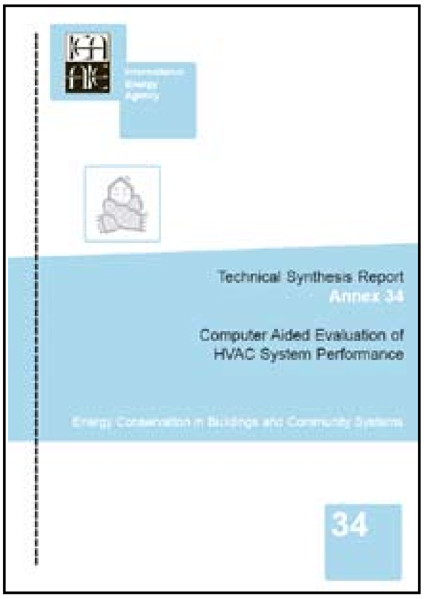
Computer-based tools to support municipal administrations and urban planners faced with evaluating and monitoring tasks will be considered in areas A, B and C with respect to their capability and usability. In addition to that, it is planned within area D to develop a knowledge-based tool similar to the Energy Concept Advisers (ECA) for educational and government buildings. This "Community Energy Concept Adviser" will assist the conception of energy-efficiency and conservation concepts and an integrated optimization of supply structures to ensure a low fossil-energy consumption of a typical neighbourhood/quarter. This is a new approach that needs to prove that it will deliver a tool that will be usable in practice.

(3) Dissemination

All the information collected as well as task-related results will be published using a project web-page, which will serve as a means for internal exchange of documents and other material and as a means for communication with external interested persons. Content of work and progress will be documented by bi-annual newsletters to be organized by the Operating Agent. The web-page shall also offer scientific or useful other publications (or links to them).

Annex Organisation:

The Operating Agent was confirmed to be Germany, represented by R. Jank from Volkswohnung Karlsruhe (reinhard.jank@volkswohnung.com).



Technical Synthesis Report
Annex 34

Computer Aided Evaluation of
HVAC System Performance

Energy Conservation in Buildings and Community Systems

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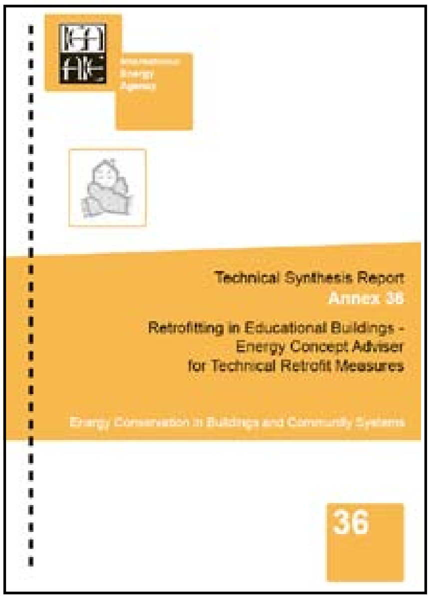

Technical Synthesis Report
Annex 36

Retrofitting in Educational Buildings -
Energy Concept Adviser
for Technical Retrofit Measures

Energy Conservation in Buildings and Community Systems

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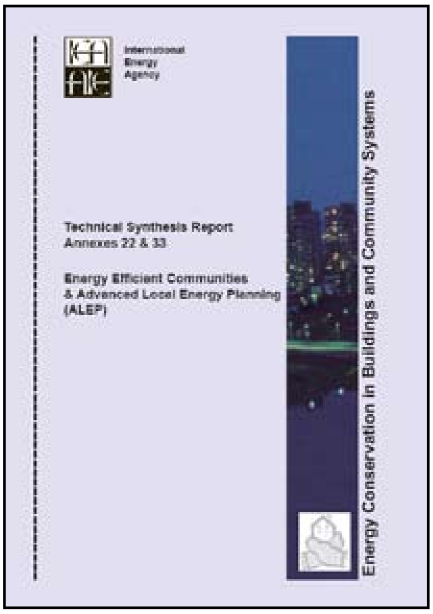


International
Energy
Agency

Technical Synthesis Report
Annexes 22 & 33

Energy Efficient Communities
& Advanced Local Energy Planning
(ALEP)

Energy Conservation in Buildings and Community Systems

ECBCS Technical Synthesis Reports

These reports give accessible summaries of individual ECBCS research projects

Low Exergy Systems for High Performance Buildings and Communities

Dietrich Schmidt, Herena Torío, ECBCS Annex 49

Introduction

The ECBCS project “Low Exergy Systems for High-Performance Buildings and Communities” will investigate the benefits of applying the exergy concept to the design and optimization of energy supply systems for buildings and communities. The project has been running since November 2006, and is currently in its second work year. Approximately 18 research institutions and universities from 12 countries are participating. The fourth expert meeting was held in Borgarnes (Iceland) on the 27th and 28th of August 2008.

The Low Exergy (LowEx) approach entails matching the quality levels of the energy supply and demand, in order to streamline the utilization of high-value energy resources and minimize the irreversible dissipation of energy. Since the exergy content required to meet the demands for the heating and cooling of buildings is very low, and the respective desired room temperature levels are very close to ambient conditions, low exergy sources (e.g. environmental heat, or the coolness of the ground) should be used to provide this demand. In turn, high quality energy sources should instead be used to supply high quality energy demands, such as electricity production or industrial processes.

A suggestion for quantification and graphical interpretation of this approach has been worked out. The suitability of a given system for a certain use can be developed by comparing its exergy efficiency for providing that use against the Primary Energy Ratio (PER), which represents the ratio between total primary energy supplied and the fossil part of that primary energy flow. In Figure 2, several energy systems for heating and cooling are analyzed following these criteria: higher PER ratios and higher exergy efficiency indicates a more efficient and optimized system configuration.

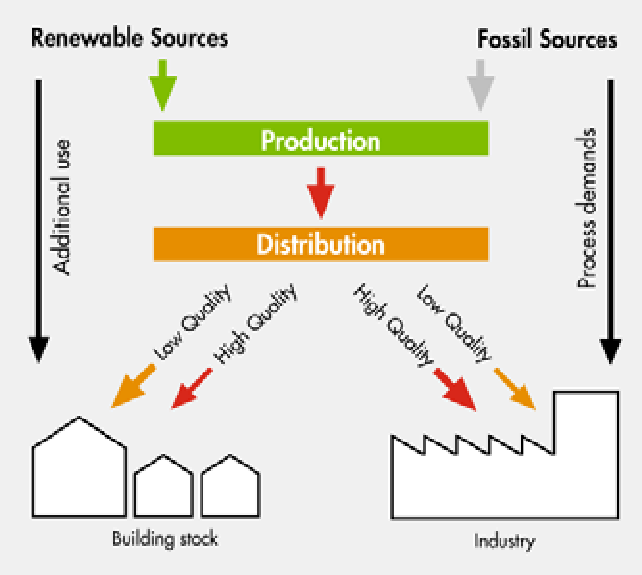


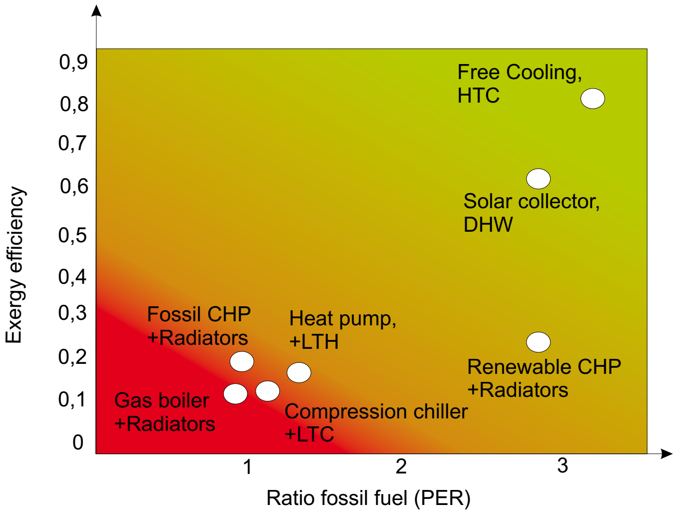
Figure 1. Desirable energy and exergy flow to the building stock and industrial applications

This approach implies working with the whole energy chain by taking into consideration the different quality levels involved, from generation to final use, in order to significantly reduce the fraction of primary or high-grade energy used and thereby minimize exergy consumption for a given utilization or maximize exergy efficiency of the overall system.

Exergy demands for heating and cooling need to be reduced first and, then, supply systems which only use low quality energy need to be utilized. For this aim, the development and implementation of new innovative forms of technology are required at the building level. To reach this aim, waste-water heat recovery for powering heat pumps, innovative evaporative chillers, and using the ground as heat and cold storage are some of the concepts being analyzed within the project too.

At the same time, as the use of high quality energy for heating and cooling is reduced, there is more reason to apply an integral analysis, which includes all other processes where energy/exergy is used in buildings, and which even broadens the scope to evaluate community supply structures. A simplified Excel tool for assessing the suitability of energy supply structures at the community level is also under development.

Some of the main research directions and design principles derived from the exergy approach during the working phase of this project are:



LTC, Low Temperature Cooling
HTC, High Temperature Cooling (LowEx)
LTH, Low Temperature Heating (LowEx)
CHP, Combined Heat and Power
DHW, Domestic Hot Water

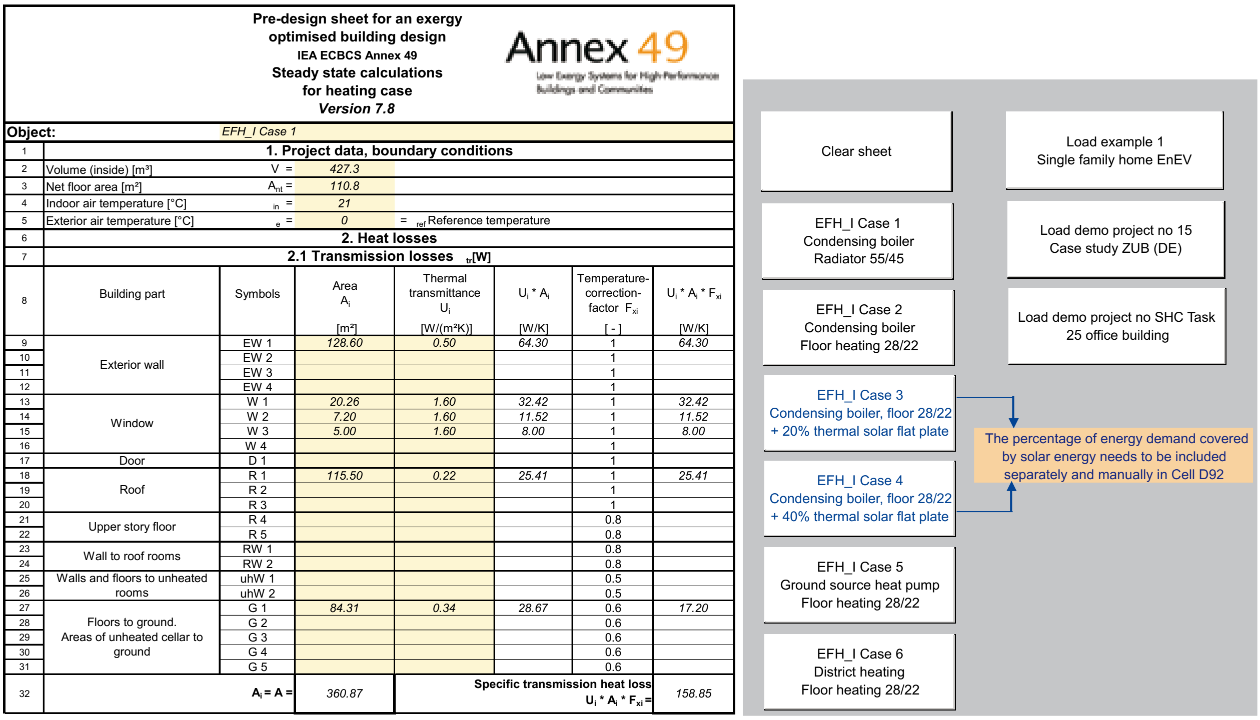
Figure 2. PER ratios and exergy efficiencies for several building heating and cooling systems

- Cluster energy demands according to their quality level
- Check cascading possibilities for supply energy demands with different exergy levels
- Further development of building systems and energy supply structures in order to enhance the use of low exergy (e.g. environmental heat) sources
- Focus on the need for the development of building technologies which allow for the enhanced use of local renewable energy sources
- Indicate the need for the development of control strategies for maximizing indoor comfort while minimizing exergy demand for energy supply systems
- Develop a holistic system approach to investigate the dependencies between energy production and the use of energy in buildings. This implies the feedback and response of the building to the grid and energy production strategies.

Tools for Exergy Analysis

To bring the application of the exergy concept within the built environment closer to the broader public, the following tools are being developed:

- A simplified Excel-based tool for steady-state exergy analysis of different building heating systems: the tool is focussed at the building level and allows the combination of several building systems to be analyzed, giving an idea of their exergy performance and suitability in providing heating demands.
- Several models for the dynamic analysis of building systems have also been developed in the Modelica modeling code. Although not compiled into a single tool, the models can be combined as modules, allowing for the evaluation of a great


Pre-design sheet for an exergy optimised building design
IEA ECBCS Annex 49
Steady state calculations for heating case
Version 7.8

Object: *EFH_I Case 1*

1	**1. Project data, boundary conditions**						
2	Volume (inside) [m³]	V =	*427.3*				
3	Net floor area [m²]	A_{nt} =	*110.8*				
4	Indoor air temperature [°C]	$_{in}$ =	*21*				
5	Exterior air temperature [°C]	$_e$ =	*0*	= $_{ref}$ Reference temperature			
6	**2. Heat losses**						
7	**2.1 Transmission losses $_{tr}$[W]**						
8	Building part	Symbols	Area A_i [m²]	Thermal transmittance U_i [W/(m²K)]	$U_i * A_i$ [W/K]	Temperature-correction-factor F_{xi} [-]	$U_i * A_i * F_{xi}$ [W/K]
9	Exterior wall	EW 1	*128.60*	*0.50*	*64.30*	1	*64.30*
10		EW 2				1	
11		EW 3				1	
12		EW 4				1	
13	Window	W 1	*20.26*	*1.60*	*32.42*	1	*32.42*
14		W 2	*7.20*	*1.60*	*11.52*	1	*11.52*
15		W 3	*5.00*	*1.60*	*8.00*	1	*8.00*
16		W 4				1	
17	Door	D 1				1	
18	Roof	R 1	*115.50*	*0.22*	*25.41*	1	*25.41*
19		R 2				1	
20		R 3				1	
21	Upper story floor	R 4				0.8	
22		R 5				0.8	
23	Wall to roof rooms	RW 1				0.8	
24		RW 2				0.8	
25	Walls and floors to unheated rooms	uhW 1				0.5	
26		uhW 2				0.5	
27	Floors to ground. Areas of unheated cellar to ground	G 1	*84.31*	*0.34*	*28.67*	0.6	*17.20*
28		G 2				0.6	
29		G 3				0.6	
30		G 4				0.6	
31		G 5				0.6	
32		**A_i = A =**	*360.87*	**Specific transmission heat loss $U_i * A_i * F_{xi}$ =**			*158.85*

The percentage of energy demand covered by solar energy needs to be included separately and manually in Cell D92

Figure 3: Screenshot from simplified excel tool for exergy analysis at the building level

variety of building systems.

- A simplified tool, also excel based, is being developed for analyzing the exergy performance energy supply structures at the community level. This is meant as a help to municipalities and decision makers involved in the community design process in the planning of optimized energy supply structures. With the help of this tool, a quantitative and qualitative view on potential improvements in such structures can be gained.

Mid-term Report

Currently, a mid-term report on the topic "Framework for Exergy Analysis on the Community and Building Level" is being compiled, summarizing some of the main results from the research activities within the group.

The report includes an introduction to and discussion on different existing methodologies for applying exergy analysis to the built environment. Benefits and drawbacks from steady-state and dynamic analyses are summarized, as well as discussions on the definition of the reference environment. Particular emphasis is given to the exergy analysis of renewable energy systems for the heating and cooling of buildings. The main outcomes from an extensive literature review on this issue are also included.

In order to characterize the exergy performance of buildings and help to communicate the concept to a wider audience, several benchmarking criteria have been analyzed and concrete benchmarking proposals have been worked out. They are also described and applied to particular case studies.

Finally, several case studies designed according to the LowEx principles, both at community and building levels, are presented in the report.

Joint IEA LowEx-DHC Workshop

On the 29th of August 2008, a common workshop took place in Reykjavik, with participants from ECBCS Annex 49 and the Implementing Agreement District Heating and Cooling (DHC) on "District Energy Futures". District heating and cooling supply structures, especially those providing waste heat from industrial processes and residual heat from CHP units, are very suitable systems for supplying energy demands in buildings from an exergy perspective, particularly if low temperature heating and high temperature cooling systems are implemented within buildings. For an optimization, a holistic approach, which includes the combined analysis of the district heating and cooling structures with the buildings and their thermal loads, is of great interest. In the workshop, an introduction to the LowEx approach, as well as its application in several case studies, was presented. In addition, the main future development trends for DHC structures were pinpointed and, thereby, important synergies between both fields of research were identified.

Further Information: www.annex49.com

Figure 4: Community case study "Alderney"

Whole Building Heat, Air and Moisture Response – A Successful Project that Exceeded Expectations!

Hugo Hens, ECBCS Annex 41

Introduction

HVAC-systems are typically dimensioned to keep the indoor temperature at comfort level under extreme outdoor weather conditions. Indoor relative humidity, however, is mostly kept free floating, as it is perceived to be less important. In addition, few take into consideration the whole heat, air, moisture balances between the building's interior, its envelope and the outside. This is a pity, as air pressure gradients may generate airflows which change the heat, air and moisture response of the envelope and building drastically. Hygric buffering in turn dampens indoor water vapor pressure fluctuations compared to outdoors. Air flows, rain penetration and moisture deposits in the envelope not only negatively affect energy consumption, but also may have a detrimental influence on the envelope's durability. Simultaneously, indoor relative humidity may affect the perceived indoor air quality and become a driving force for mould and dust mite infection.

Clearly, whole building heat, air and moisture response can have an impact on human comfort, indoor environment, energy consumption and envelope durability, all reasons in 2003 for the project's initiation.

Project Objectives

The project aimed to develop a holistic view of the overall HAM transfer between the building's interior, the enclosure and the outside. Specific objectives were:

1. Explore the physics involved in whole building HAM response
2. Analyse the effects of whole building HAM on comfort, indoor environment, energy consumption and enclosure durability.

Project Organisation

The work was structured into four areas of research:

1. Modelling principles and common exercises
2. Experimental investigation
3. Boundary conditions
4. Applications

Project Results

Area 1: Modelling Principles and Common Exercises

This subtask concentrated on whole building HAM modelling. The models that were verified and validated using common exercises took into account parameters such as location and orientation of the building, the HVAC-system, adventitious and user-defined air flows, moisture response by sorption-active finishes, furniture and furnishings, the type of room (bathroom, living room, etc.) and user's behavior (number of people, activities that released moisture and heat, frequency and duration of window ventilation). The schedule of common exercises was as follows:

> *Exercise 0:* Dry BESTEST. Verification of the thermal part of the models by inter-model comparison
>
> *Exercise 1:* Wet BESTEST. Generating vapor in the BESTEST building, predicting the inside relative humidity in isothermal and transient conditions. Verification by inter-model comparison
>
> *Exercise 2:* Validating models by simulating experimental results at test box level under isothermal conditions
>
> *Exercise 3:* Validating models by simulating experimental results in a test room and reference room under non-isothermal conditions
>
> *Exercise 4:* Energy consumption in the test room of Exercise 3, assuming a humidity controlled ventilation system. Verification by inter-model comparison
>
> *Exercise 5:* Real world application. Looking to the ability of the participants to handle a typical moisture damage case by using simple models
>
> *Exercise 6:* Experimental work on a coupled room configuration under isothermal conditions

The objective of *Exercises 0 and 1* was to verify models. The results were disappointing, especially when humidity was added. But even without humidity, the variance between the many solutions was not less than noted in ECBCS Annex 10 (Building HEVAC System Simulation). *Exercises 2 and 3* were conceived to validate the models. The results show that common assumptions, such as ideal air mixing, could produce predictions that deviate from the measured data. Of course, measured data also show uncertainty, which must be taken into account. *Exercise 4* looked at the ability of whole building HAM-models to predict net energy demand. *Exercise 5* offered the participants the possibility of explaining a real life problem and proposing solutions, while *Exercise 6* produced a set of very interesting measured data that may be useful for future validation of new models, including CFD-tools. The exercises allowed the participants to refine their models (Rode et al, 2008).

Area 2: Experimental Investigation

Here, moisture buffering in finishing materials, furniture and furnishings was the main topic. For that, a round robin on vapor permeability and adsorption/desorption of painted and unpainted gypsum board was organized. The data produced was equivocal, as large differences in measured vapor permeability were noted between the participating laboratories, which could not be explained otherwise than by measuring errors. One of the conclusions was that future standards should include more precise and restrictive information on how to prepare the samples, how to vapor-tighten the joint between the sample and the cup and how to perform the tests (duration, number of measuring moments, time interval between measurements, etc). Also the adsorption/ desorption data showed dispersion. Chemical-bound water molecules in Gypsum are easily released when dried at higher temperatures.

Two additional tests were organized, one looking at buffering by the same gypsum board used in the round robin in response to a stepwise and sinusoidal change in relative humidity and the other looking to the humidity build-up in a pile of gypsum boards in response to a sudden change in relative humidity. Simulation of the first test show large spreads between the different solutions. The second test was quite well reproduced by all models. Some tried CFD, in combination with a material model. The first trials showed large differences with the measured data. Follow-up trials, however, did quite well.

Apart from the testing and validating activity, a new track in simplified modelling was explored, using a short term (1 h) and mid-term (8 hrs) moisture buffering value (MBV). The concept was developed in the Nordic countries. It gives the humidity uptake per percent change in relative humidity for 1 m² of a surface or for an object exposed to 1 (short) or 8 hours (mid) at 75% relative humidity, followed by 23 (short) or 16 hours (mid) at 33% humidity. The MBV-value is quite easily measurable (Figure 2). The annex extended the concept from the 1 m^2 and one object level to room level, among others based on experimental and modelling work (Roels et al, 2008).

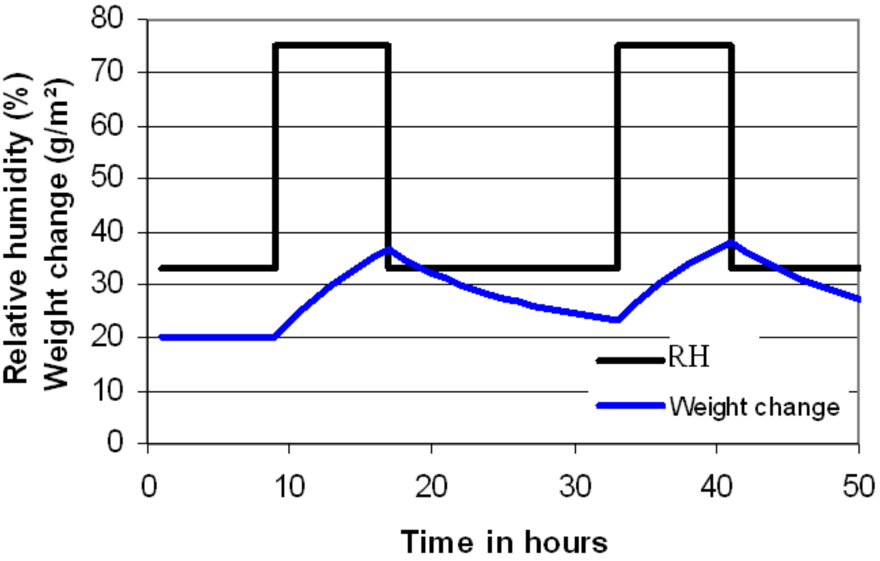


Figure 1: Measuring the moisture buffering value

Area 3: Boundary Conditions

The indoor part was mainly devoted to measuring temperature and relative humidity in residential buildings, student homes and schools, to a literature review of moisture production and building usage schedules and to an evaluation of simple indoor humidity calculation tools. Included were the EN climate class model (Figure 3), the ASHRAE SPC 160P—Design Criteria for Moisture Control in Buildings – 2003 proposal and the Jones model, which accounts for buffering. The EN climate class model was also controlled using the indoor data measured. The results deviated quite substantially from the EN curves. In particular the water vapor excess zero at 20°C outside and the excess slope zero below 0°C, were questionable. Special attention went to the convective surface film coefficient for heat and mass, and to the air pressure gradients between in- and outdoors. In both cases, literature reviews were complemented with experimental and CFD-work.

Outdoor conditions were restricted to wind-driven rain, under-cooling and climate change. The wind-driven rain activity crystallized around two exercises. First, participants were asked to simulate the rain impact on a series of building configurations, tested beforehand in a wind tunnel, by using simplified methods and CFD/rain drop trajectory calculations. Then, CFD/rain drop trajectory codes were validated by simulating the rain load on a Norwegian test building and comparing the results with the wind-driven rain load and local climate data monitored on site. While the simplified models gave results that deviated quite substantially from the wind tunnel and CFD/rain drop trajectory calculations, the CFD/rain drop trajectory-validation exercise did quite well (Kumaran et al, 2008).

Area 4: Long Term Performance and Technology Transfer

Quite some time was devoted to studying the impact of low and high relative humidity on human health and comfort. Also the indoor conditions in museums, monuments and landmark buildings were a topic of concern. Further on the annex looked to recent advances in mould and mildew research, with isopleth interpretation, sensitivity of substrates for mould infestation and mould growth modelling as specific topics. A question of importance was the energy benefit of demand controlled ventilation in combination with indoor moisture buffering. Results presented ranged from hardly any difference to measurable net energy demand gains in winter and summer.

Also the effect of air permeability on interstitial condensation in roofs was tackled as was attic ventilation. Here, two different answers were given. The UK seemed quite sure that correct ventilation in combination with best achievable ceiling air-tightness diminished condensation to an acceptable level. Sweden instead introduced fan-controlled attic ventilation. The basis for their proposal was simulations on a reference attic volume, which showed that even a perfectly air-tight ceiling did not prevent nighttime underlay wetting by under-cooling. When happening, fan driven attic ventilation provides daytime drying as long as the outdoor conditions are favorable for it (Holm et al, 2008).

Conclusion

Annex 41 had a huge program to cover. The initiative motivated 18 countries and more than 100 experts to participate. This underlines the interest in the topic and the expectation people had about an activity that not only generated a better understanding of the whole building heat, air and moisture response but also established ways on how to benefit from that knowledge in terms of better comfort, better indoor air quality, better durability and less energy consumed.

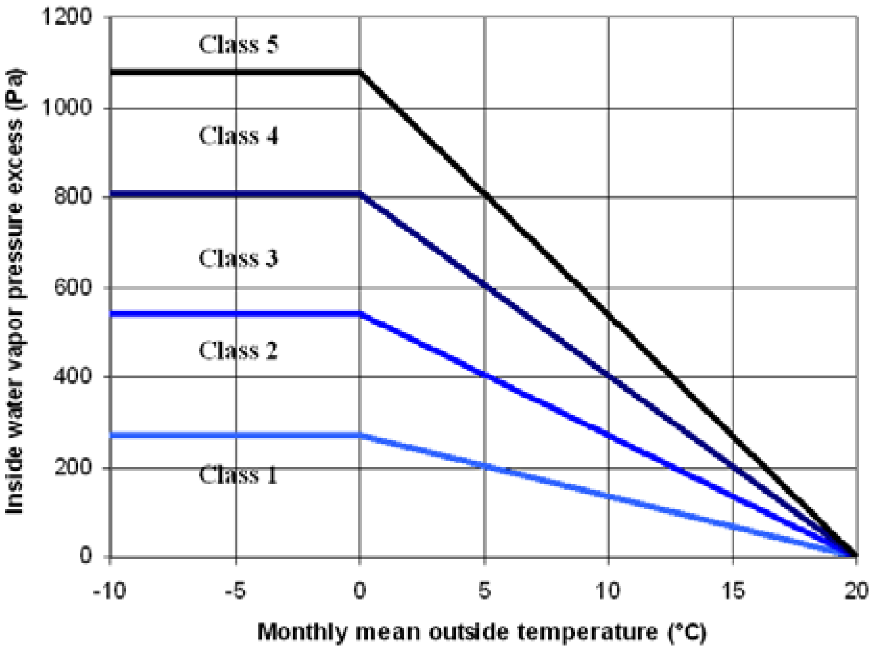


Figure 2: The EN climate classes

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