LowEx

LOW EXERGY GUIDEBOOK IN 2004 OFFERS BASIC KNOWLEDGE OF HEATING AND COOLING SYSTEMS FOR SUSTAINABLE BUILDINGS

This issue is the last issue of the LowEx News – the biannual newsletter published during the working phase of IEA ECBCS Annex 37. The results of Annex 37 are described here together with the formats of the final products of the Annex. In this issue you can also find an article about the newly founded LowExNet. The Annex 37 group considered it very important to continue working together to further promote the use of exergy concept in connection with buildings as well as the low exergy systems for buildings. As a result of this desire, an International Society for Low Exergy Systems in Buildings (short: LowExNet) was founded on September 13th during the last Expert Meeting of Annex 37 in Kassel, Germany.

The final products of Annex 37 will be published in many formats.

GUIDEBOOK FOR LOW EXERGY SYSTEMS

The results of Annex 37 will be presented in a form of a booklet of about 40 pages, which includes the LowEx Guidebook in a CD-ROM format. The CD-ROM will be user friendly and the results will be presented visually and interactively. It will contain all the material produced within the project; newsletters, publications, the exergy analysis tools and the full version of the guidebook (also as a printable .pdf version). In addition a web-site containing the same information as the CD will be set up. The final products will be officially published in June 2004.

The full version of the guidebook will include edited versions of the working papers written during the Annex, some summary tables and also material, which is exclusively written for the guidebook (Table of contents on page 2).

LOW EXERGY SYSTEMS FOR BUILDINGS

An essential aim of the Annex 37 working group has been to open up opportunities for increasing energy savings and reducing emissions from buildings. The group wants to promote a more efficient use of energy by means of facilitating and accelerating the use of low valued and environmentally sustainable energy sources for the heating and cooling of buildings.

Heating and cooling systems that work at a temperature close to room temperature (i.e., low exergy systems) are a prerequisite for the efficient utilisation of low valued energy sources. Since heat and cold emission systems (e.g., floor and wall heating) have a life cycle of 40 to 50 years, low exergy systems should be applied as soon as possible in order to realise the use of low valued energy sources within the next half century.

LOW EXERGY GUIDEBOOK IN 2004 OFFERS BASIC KNOWLEDGE OF HEATING AND COOLING SYSTEMS FOR SUSTAINABLE BUILDINGS...

The table of contents of the LowEx Guidebook.

Mia Ala-Juusela, VTT Building and Transport, Finland and Dietrich Schmidt, KTH Building Technology, Sweden

BUILDINGS FOR A SUSTAINABLE WORLD

The question of how to build sustainable houses has been a constant source of discussion in recent years. A highly efficient usage of energy and all of the potentials in the involved energy flows are undisputably mandatory for that. Taking into account the qualitative aspects of energy use leads to the introduction of the exergy concept, which has been the key concept of Annex 37.

EXERGY CONCEPT

To find and to quantify further reduction potentials in energy use, the thermodynamic concept of exergy can be beneficial. Exergy is energy, which is entirely convertible into other types of energy. Energy, which has a very limited convertibility potential, such as heat close to room air temperature, is low valued energy.

Low exergy heating and cooling systems use low valued energy, which could also easily be delivered by sustainable energy sources (e.g. by using heat pumps, solar collectors or others). Common energy carriers like fossil fuels deliver high valued energy. The idea of exergy not only enables us to estimate the amount of used or required energy, but in addition, the potentials and the quality of these can be calculated.

EXERGY ANALYSIS

Based on these fundamentals, a calculation and analysing method for buildings, applying the exergy concept, was developed during Annex 37. The importance of low temperature heating and high temperature cooling emission systems can be shown.

LOWEX COMPONENTS

With appropriate emission systems, the overall system design of a building is flexible in meeting future requirements, and they are open to being supplied by low temperature energy sources. There are already a number of different low temperature components, systems and technologies on the market.

LOWEX BUILDINGS

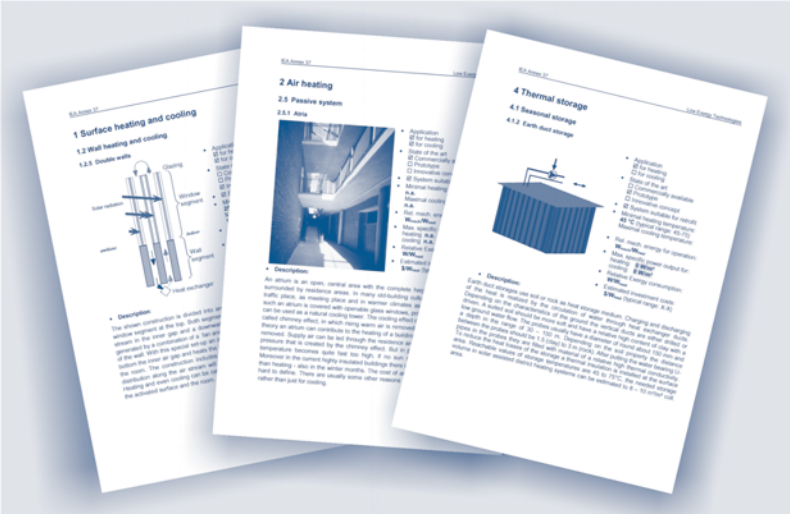
From the LowEx components, different systems can be compiled for LowEx buildings. There are examples of LowEx buildings from all over the world and from all kinds of buildings, from newly erected to retrofit, from dwellings to commercial buildings, and also cultural monuments, such as churches and castles.

MARKET POTENTIALS

According to a litterature review and occupant surveys supported by experiences from the cases, the LowEx systems offer some additional benefits besides the desired heating and cooling effect. These include energy savings, better thermal comfort and internal air quality. Analyses made during Annex 37 of the potentials for market implementation of LowEx systems in different countries show that LowEx systems are well received and the benefits are highly appreciated. With this strong evidence in hand, it is easy to say that applying LowEx systems to buildings give great potential in creating a sustainable built environment both inside and outside the building itself. ■

DATABASE FOR QUICK OVERVIEW OF
POSSIBILITIES AND LIMITATIONS OF LOWEX TECHNOLOGIES

The LowEx Guidebook contains a database of low exergy heating and cooling systems for buildings. The database consists of 64 information sheets, which describe the technologies; their basic principles, technical risks and benefits, advantages, limitations and state-of-art (commercially available, prototype or innovative concept). The idea is to give a quick overview of the possibilities and limitations of the technologies. Guidelines for how to compile a system from these components are also given in the Guidebook. Some system descriptions are also included.



In the beginning of each data sheet there is a picture and some main data about the concept.

In the database of low exergy heating and cooling systems for buildings, the systems are divided into the following groups:

- Surface heating and cooling systems (floor, wall and ceiling heating and cooling, local heaters or phase change on material surfaces)
- Air heating and cooling systems (air-to-air heat exchangers, water-to-air heat exchangers, steam or vapour-to-air heat exchangers and passive systems like atria or evaporative cooling)
- Metabolic systems (biological systems like bacteria, animals or plants)
- Generation/conversion of heat and cold (boilers, heat pumps, solar collectors, CHP, waste heat, fuel cells and biological systems)
- Thermal storage (seasonal or short term)
- Distribution systems (liquid or air as transfer medium)
- Community systems (district heating and cooling). ■

EXERGY ANALYSIS TOOLS FOR
PRE-DESIGN OF ENERGY SYSTEMS IN BUILDINGS

To increase the understanding of exergy flows in buildings and to be able to find ways to further reduce the energy use, two pre-design analysis tools have been produced during ongoing work for the IEA ECBCS Annex 37. These tools will be parts of the CD-ROM that is the final report of the Annex. The printed version of the Guidebook will include descriptions of the tools.

Today calculations of the energy use in buildings are based on the energy conservation principle, the first law of thermodynamics, only. But the energy conservation concept alone is not adequate enough to gain a full understanding of all the important aspects of energy utilisation processes. Instead, the method of exergy analyses based on a combination of the first and second law of thermodynamics is the missing link needed to fill the gap in understanding and designing energy flows in buildings. Utilising the exergy concept, two pre-design tools have been programmed by the Annex 37 working group. The pre-design tools are meant for simple steady-state and annual energy and exergy analysis of buildings.

GUIDELINES FOR EXERGY ANALYSIS

In the preparation phase, the working group set as an objective to collect the tools readily available on the market and to review them from the viewpoint of adaptability for exergy analyses. Quite quickly we realised, that there were no representative off-the-shelf tools suitable for exergy analysis of buildings. Because it was not possible to develop a very sophisticated tool in the frame of the Annex 37, the participants decided to give guidelines for tool developers. The guidelines include models for exergy analysis of different systems. They are presented in chapter 2 of the Guidebook.

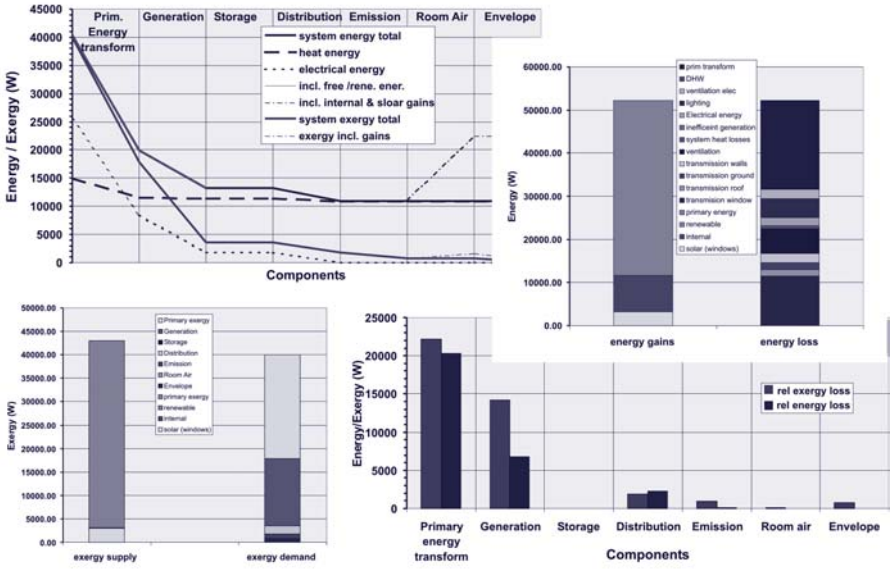


Figure 1. The results of the tools are presented graphically.

TWO PRE-DESIGN TOOLS

The participants also recognized the importance of developing a simplified tool to visualise why low exergy systems would be advantageous in some energy chains compared to high exergy systems. This tool should be easy to use and show the exergy flow through a system or energy chain. Finally, two pre-design tools were developed.

STEADY-STATE HEATING TOOL

Throughout the development of the steady-state Heating tool, the aim was to produce a "transparent" tool, easy to understand for the target group of architects and building designers, as a whole. Other requirements were that the exergy analysis approach is to be made clear and the required inputs need to be limited. Today, the Microsoft Excel spreadsheet based tool has two input pages and results are summarised on two additional pages with diagrams (Figure 1).

All steps of the energy chain – from the primary energy source, via the building, to the sink (i.e. the ambient environment) – are included in the analysis. The entire tool is built up in different blocks of sub-systems for all important steps in the energy chain. All components, building construction parts and building services equipment have sophisticated input possibilities. Heat losses in the different components are regarded, as well as the required auxiliary electricity for pumps and fans. The electricity demand for artificial lighting and for driving fans in the ventilation system is included. A collection of different parts of the heating system can be chosen from a list.

EASY-TO-USE TOOL FOR HEATING AND COOLING

The objective of the "Pre-Design Tool for Energy and Exergy Analyses of Heating and Cooling Applications in Buildings" is to provide a designer or a user with a simple tool that presents rough energy and exergy estimates of various low temperature heating and high temperature cooling technologies in buildings. For this purpose, the tool includes a program that estimates the heating and cooling requirements of a building using the well-known modified-bin method.

The heating and cooling requirements are estimated using descriptive data where the user should enter the physical characteristics of the building and the characteristics of the site. Rough energy and exergy analyses are carried out on the system components of selected heating and cooling technologies. The exergy analysis is carried out using estimated quality factors of the energy flow in the system.

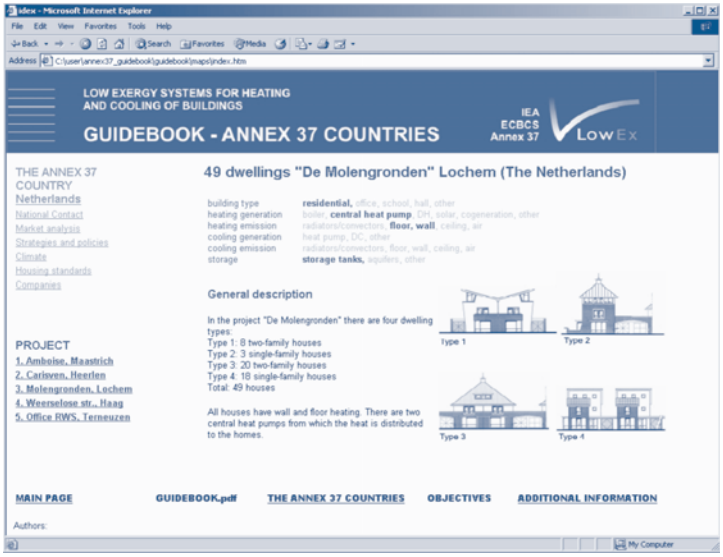
MAIN DIFFERENCIES BETWEEN THE TOOLS

The tools give outputs in similar formats. The main differencies are, that the Heating and Cooling tool is even more easy-to-use than the steady-state Heating tool, but it is therefore also less flexible. In the steady-state Heating tool the user has more options for the input parameters, but then the user has to know more about the building and its systems. The steady-state Heating tool does an analysis of a single moment, but the Heating and Cooling tool gives an estimate of the annual energy and exergy demand of the building. ■

Mia Ala-Juusela, VTT Building and Transport, Finland; Abdelaziz Hammache, Natural Resources Canada, Canada and Dietrich Schmidt, KTH Building Technology, Sweden

SHOWING GOOD EXPERIENCES FROM MANY COUNTRIES

In the WebGuidebook and the CD-ROM, each case will be presented with a front page from which the reader can click to the more detailed description.



The LowEx Guidebook presents 30 case examples of LowEx buildings from 11 countries. The case examples show the wide variety of applications of low exergy systems. They also demonstrate the flexibility of the systems with regard to the energy source. There are examples of low exergy systems in dwellings and offices, but also in a museum, a church and a concert hall. In these examples there are systems that use heating or cooling energy from sun, ground, district heating network as well as electricity or gas network. The experiences from the case examples also prove the findings from the litterature: In addition to the desired heating or cooling effect, low exergy systems can provide occupants with a comfortable, clean and healthy environment.

BIG VARIETY OF DEMONSTRATION PROJECTS

Demonstration projects have been submitted from 11 countries. With 30 cases, distributed over new and existing buildings, residential and non-residential buildings with various technologies and emission systems this gives a good overview. Tables 1 and 2 show the distribution of the cases. Most cases are new residential buildings. Floor heating is the most commonly used emission system in the case buildings. Most of the cases are low temperature heating cases; only 12 cases are high temperature cooling cases.

ADDITIONAL BENEFITS PROVEN BY THE CASES

In addition to the desired heating or cooling effect, low exergy systems can provide occupants with a comfortable, clean and healthy environment. In the Guidebook, findings from the literature are described, extended with an occupant survey that has been completed in the Netherlands, and which correspond with the findings. Also the measurement data from the demonstration buildings give same kind of results.

The application of low exergy systems provides many additional benefits besides energy supply, such as: improved thermal comfort, improved indoor air quality and reduced energy consumption. These aspects must be promoted to increase the application of low exergy systems for heating and cooling of buildings.

The Dutch occupant survey shows that all low temperature systems are well received. In particular, the occupants found the indoor climate to be significantly better in dwellings with floor and wall heating compared their previous dwellings. The main disadvantage was the controllability. The advantages and disadvantages, mentioned by the occupants in the survey, are similar to results in the literature.

The measurement campaigns and occupant questionnaires from the case examples prove the findings from the litterature review and the Dutch occupant survey. It is especially delightful to read the results of some refurbishment cases: it is evident, that the refurbishment is usually meant to improve the situation, but it seems that the new low exergy systems have surpassed the expectations of the occupants. Also, in these examples the comparison between high and low exergy systems is even more indisputable, because the houses and the occupants are the same in both cases. ■

Mia Ala-Juusela,
VTT Building and Transport, Finland

Type of building	Number of cases
New residential	10
Existing residential	5
New non-residential	9
Existing non-residential	3+3

Table 1. Distribution of building types in LowEx demonstration projects.

Emission system	Number of cases
LT floor	14
LT wall	6
LT ceiling	4
LT radiator/conv	9
LT air	8
Cooling beams/radiative panels	2
Activated thermal slab	2
Combined systems	15

Table 2. Distribution of emission systems in LowEx demonstration projects.

LOWEXNET –
INTERNATIONAL SOCIETY FOR LOW EXERGY SYSTEMS IN BUILDINGS

The low exergy approach should be the key concept in any long-term strategy aiming at creating a sustainable built environment. As the work of Annex 37 for making a LowEx Guidebook is nearly finished, the Annex 37 working group considered it very important to continue working together to further promote the use of this concept. The discussions during the Annex 37 Expert meeting in Kassel, Germany led to the founding of the International Society for Low Exergy Systems in Buildings (short LowExNet) on the 13th September 2003.

Dietrich Schmidt,
KTH Building Technology, Sweden

At their meeting at the Centre for Sustainable Building (ZUB) in Kassel, the Annex 37 group decided to continue working together within an International Society of Low Exergy Systems for Buildings.

The main objective of this network is to formulate our interest in the regarded topics beyond the working time of the IEA Annex 37 itself. It is planned to have workshops in connection with other international events. The first LowExNet Workshop will be held in Rovaniemi, Finland in connection with the last Annex 37 meeting. It is planned to discuss new and also forgotten-ancient concepts, technologies and applications of LowEx systems. LowExNet will cover applications in countries outside the IEA, like those in Latin America and Africa. All information will be available on a website (http://www.lowex.net/).

Masanori Shukuya was nominated as the first chairman, Dietrich Schmidt as the first operating agent. Gudni Johannesson, Markku Virtanen, Paul Ramsak, Johann Zirngibl, Elisa Boelmann and Lars Kühl agreed to become board members. The Centre for Sustainable Building in Kassel will host the network in the beginning. ■

MARKET IMPLEMENTATION AND STRATEGIES TO STRENGTHEN THE DEMAND OF LOWEX SYSTEMS

An analysis of the market implementation of the LowEx systems was made in the participating countries. Also the national strategies and policies were studied to see, if they are favourable for the LowEx systems or not.

MARKET ANALYSES

Principal contractors, architects, consultants, manufacturers and suppliers, installers and end users in the participating countries were asked about their

- Recognition of the name LTS (Low Temperature Systems)
- Associations / feelings towards these systems
- Attitude towards extra investments
- Appreciation of thermal comfort as a target; strategic significance

The results of the national market analyses were collected in a table format to get a quick overview from each country.

STRATEGIES

The national building codes and energy strategies were studied to find out if they contain something that will favor or prevent the implementation of the LowEx systems on the national market. Descriptions of the national strategies and policies compose chapter 7 of the Guidebook. ■

ANNEX 37 NEWSLETTERS

All the eight issues of the LowEx News can be found in pdf format at the Annex 37 website with a short description of every newsletter. This is also the way they are going to be presented in the Guidebook.

LAST MEETING OF ANNEX 37

The Final meeting of Annex 37 will take place on 19th and 20th January, 2004 in Rovaniemi, Finland. The first Workshop of the newly founded LowExNet will be held in connection with this meeting on 20th January.

ANNEX 37 WEBSITE

LowEx

HTTP://WWW.VTT.FI/RTE/PROJECTS/ANNEX37/

On the Annex 37 website we have collected information about Annex 37: background, objectives and working methods as well as information on participants, meetings and publications. The website is updated continuously, so the latest information will always be found on the website. There you can find the

- Contact information
- Status reports
- Previous issues of LowEx News (in pdf format)
- Technical Presentations about Annex 37 issues in ECBCS ExCo meetings
- Links to other useful sites

SUMMARY OF (LIMITED) MARKET ANALYSIS ON LTS IN CANADA

	Principal contractors	Architects	Consultants	Manufacturers and suppliers	Installers	End users
Recognition of name LTS	Not familiar with the term, but with the concept	No	No	Yes	Yes	No
Associations / feelings	Like it, more comfortable heat	Great for residential, but not where large air changes are required	Radiant heating, comfort	Associated with hot water and in-floor heating systems, like and promote these	Associated with in-slab heating, more energy efficient, higher capital cost	Good control, keeps everyone happy
Attitude towards extra investments	Acceptable, wise thing to do, especially given the cost of gas	Mechanical costs already too high in commercial applications	There are demontrable paybacks, extra cost for comfort is demanded by some owners	Good investment, advantages are under-rated	Like it, owners with larger capital budgets will install	Good energy saver, worth extra investment
Appreciation of thermal comfort as a target; strategic significance	Not typically appreciated by most	Most important is to give individuals control	Important for users and owners, but developers don't see the benefits	Very important, major complaint is lack of personal control	Provide more comfortable heat and are cheaper to operate	Very important, people work better when more comfortable

Based on extended single interview per target group

=Yes/positive = Neutral/inconsistent = No/negative

The market analysis of each country is summarised in this kind of table for a quick overview.

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Annex 37

LOW EXERGY SYSTEMS FOR HEATING AND COOLING OF BUILDINGS

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