ECBCS Annex 49

Low Exergy Systems for High-Performance Buildings and Communities

Newsletter No. 1 March 2007

START OF THE WORK

As a result of the discussions at the Future Building Forum "Low-E^3-Building Systems, Low Energy, Low Exergy, Low Environmental Impact", in Padova in April 2005, and with the encouragement of the ECBCS ExCo members, the International Society of Low Exergy Systems in Buildings (LowExNet) had the initiative to propose a new annex collaborative work. After that, a one year preparation phase started. Germany agreed to lead the annex and offered to provide the operating agent for it. Two preparation phase meetings were held, one in Berlin (Germany) in May, and one in Stockholm (Sweden) in October 2006. During the preparation period, a complete programme of activities, structure and deliverables was compiled.

The First Expert Meeting of Annex 49 takes place in Padova (Italy), March 19 - 21, 2007

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Participants of the preparation phase meeting in Stockholm (Sweden) in October 2006

PREPARATION PHASE

Participants from 8 countries attended the first preparation phase meeting in Berlin. Moreover, during this meeting in Berlin, several other potentially interested countries were contacted. There are currently participants from 12 countries engaged in the project. In Berlin, the main possible inputs and expected outputs were identified by the participants of the annex. These were used as starting points in defining the working program, which was reviewed, discussed and agreed upon during the second meeting, in October 2006 in Stockholm.

MILESTONES

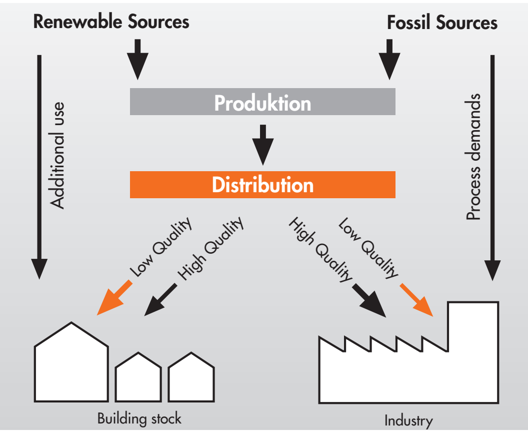
The key deliverable of Annex 49 is a report on integral optimisation strategies encompassing both buildings and supply structures. During the preparation phase, the participants agreed that a concrete definition of grades and categories for LowEx components and buildings must be fixed. Hence, as a result of discussions within the first expert meeting, a first draft of these definitions is to be produced.

In order to cover a wider climatic scope, technology transfer between countries will take place, focusing on the performance of light structures for warm climates.

In total, 25 deliverables have been identified, which have further been divided into smaller reports to be provided by the participants.

Crosslink
Activities within Annex 49 will be closely related to other research projects:

- Synergy or joint meetings with ECBCS Annex 44 "Integrating Environmentally Responsive Elements in Buildings"
- ECBCS Annex 46 "Holistic Assessment Tool-Kit on Energy Efficient Retrofit Measures for Governmental Buildings" and
- ECBCS Annex 50 "Prefabricated Systems for Low Energy Renovation of Residential Buildings" are foreseeable results
- A close collaboration with the European COST action on "Analysis and Design of Innovative Systems for Low-EXergy in the Built Environment (COSTeXergy)" is ongoing
- Close contacts to the ASHRAE Technical Group 1 "Exergy Analyses for Sustainable Buildings" have been established.



Desirable energy/exergy flow to the building stock and industry

THE ANNEX 49 PROJECT

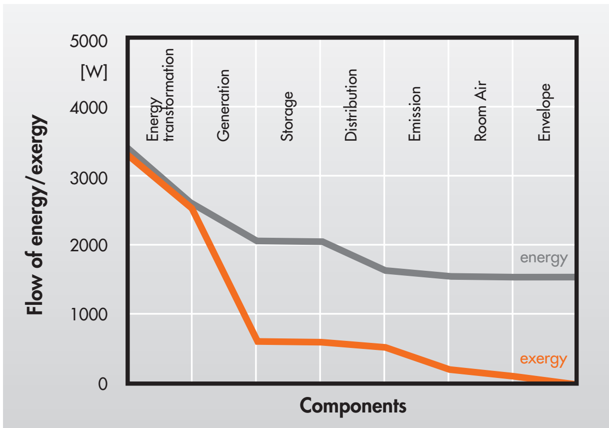
The exergy content required to satisfy the demands for the heating and cooling of buildings is very low, since a room temperature level of about 20°C is very close to ambient conditions. Nevertheless, high quality energy sources like fossil fuels are commonly used to satisfy these small demands for exergy. From an economical point of view, exergy should mainly be used in industry to allow for the production of high quality products.

The new approach is not necessarily focused on a further reduction of the energy flow through a building's envelope: when the demands for heating and cooling have already been minimised, the low-exergy approach aims at satisfying the remaining thermal energy demand using only low quality energy. Annex 49 aims at improving, both on a community and building level, the design of energy use strategies which account for the different qualities of energy sources, from generation and distribution to consumption within in the built environment.

Annex 49 is based on an integral approach which includes the analysis and optimisation of the exergy demand in the heating and cooling systems as well as in other processes where energy/exergy is used within the building stock.

It is known that the total energy use caused by buildings accounts for more than one third of the world's primary energy demand. There is, however, a substantial saving potential in the building stock. The implementation of exergy analyses paves the way for new opportunities to increase the overall efficiency of the energy chain.

The method of exergy analyses has been found to provide the most correct and insightful assessment of the thermodynamic features of any process and offers a clear, quantitative indication of both the irreversibilities and the degree of matching between the resources used and the end-use energy flows.



Energy and Exergy flows through a building

OBJECTIVES

The main objective of Annex 49 is to develop concepts for reducing the exergy demand in the built environment, thus reducing CO_2 emissions from the building stock and supporting structures for setting up sustainable and secure energy systems for this sector.

Specific objectives are:

- to use exergy analysis to develop tools, guidelines,recommendations, best-practice examples and background material for designers and decision makers in the fields of building, energy production and politics
- to promote possible energy/exergy cost-efficient measures for retrofit and new buildings, such as dwellings and commercial/public buildings
- to promote the exergy-related performance analysis of the buildings, from the community level perspective

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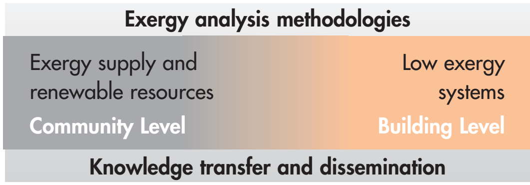


Structure of the ECBCS Annex 49

Tools, guidelines, recommendations, best-practice-examples, pre-normative proposals and background material will be developed within the frame of Annex 49.

STRUCTURE

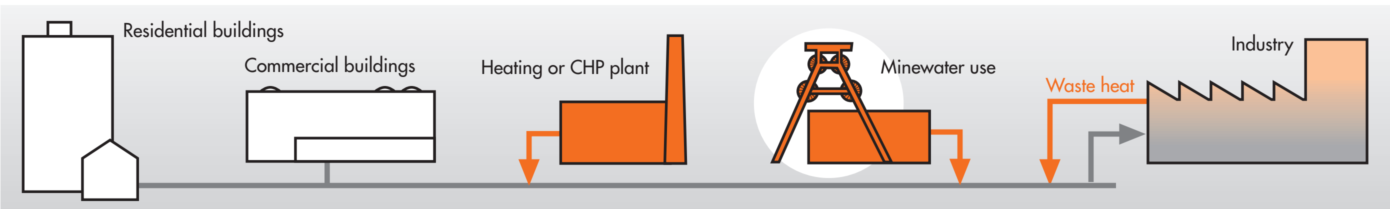
To accomplish these objectives, participants will carry out research and work on developments within the general framework of the following four subtasks.

Subtask A: Exergy Analysis Methodologies
Co-ordinator: Finland, represented by Mia Ala-Juusela, VTT Technical Research Centre of Finland.
The objective of this subtask is the development, assessment and analysis methodologies, including the development of tools for design and performance analysis of the regarded systems.

OUTCOME

The tools, guidelines, recommendations, best-practice examples, pre-normative proposals and background material developed within the framework of Annex 49 will be oriented and made available to designers, planners and decision makers in the fields of building, energy production and politics. Using results from different research projects of the participant countries, a wide range of cases will be studied. At the building level, both residential and commercial buildings will be taken into consideration.

At the community and supply level, the widest spectrum of possibilities will be assessed. In addition, several climatic conditions will be taken into account. One example of innovative community supply structure integrated with suitable advanced building design that constitutes an excellent example of the LowEx principle in practice is the Minewater project, which is described in detail in this newsletter.



The integration of energy sources from our environment, e.g. the use of water from abandoned mines for heating or cooling of buildings, requires exergy efficient supply systems at the community level and adapted building service systems.

Subtask B: Exergy Efficient Community Supply Systems
Co-ordinator: Canada, represented by Ken Church, Sustainable Buildings and Communities Natural Resources, Canada.
The main aim of this subtask is to develop exergy distribution, generation and storage system concepts that meet all exergy demands of community members with a minimum input of primary energy.

Subtask C: Exergy Efficient Building Technologies
Co-ordinator: Sweden, represented by Gudni Jóhannesson, Royal Institute of Technology.
This subtask is focused on the reduction of the energy demand for heating, cooling and ventilation of buildings. It includes the development of best-practice guidelines for implementing innovative building technology solutions, and for establishing a holistic system approach to the exergy assessment of buildings.

Subtask D: Knowledge Transfer and Dissemination
Co-ordinator: Germany, represented by Dietrich Schmidt, Fraunhofer Institute for Building Physics.
This subtask concentrates on the collection and spreading of information on ongoing and finished work, including the set-up of information platforms and the organisation of seminars and workshops.

DISSEMINATION

In addition to regular technical reports and conference papers, industry workshops will be organised periodically.

The final output shall be a guidebook on how to implement advanced LowEx technology at a community level and how to optimise supply structures in the built environment.

The design guidebook will be produced in print and on CD-ROM.

Furthermore, up-to-date information on Annex 49 can be found on our website:
www.annex49.com

The following can be found there:
• Information about and from meetings • Useful links • Information about and from the meetings • Contact information

Low exergy in practice

The Minewater Project Heerlen, the Netherlands

Peter Op 't Veld[1], Elianne Demollin-Schneiders[2]

In Heerlen, in the Netherlands, warm and cold water volumes from abandoned mines based on a low exergy energy infrastructure are used for the heating and cooling of buildings. The combination of low temperature heating and cooling transfer systems, advanced ventilation technologies and an integrated design of buildings and building services provides an excellent thermal comfort and improved indoor air quality throughout the entire year, in addition to a CO_2 reduction of 50% in comparison to a traditional solution.

Mine water utilisation for community development

Abandoned and flooded mines have a high potential for geothermal utilisation as well as heat or cold storage of water volumes in remaining underground spaces. The use of heat and cold from mine water is one of the important aspects of rational and sustainable utilisation of post mining infrastructure and may bring positive socio-economic results, social rehabilitation and improved health for communities living in European areas of (former) mining activity.

In Heerlen, the Netherlands, the redevelopment of a former mining area, including a large scale new building plan, is being executed with a low exergy infrastructure for heating and cooling of buildings, using mine water of different temperatures as a sustainable geothermal energy source. Most important however is that these sources provide low valued energy (low exergy) in large quantities.

The energy concept

For the Heerlen project, mine water is extracted from different wells with different temperature levels. In the concession of the former ON III mine (location 1 Heerlerheide) mining mining was conducted down to a level of 800m. In this concession, the warm wells (30° C) can be found. In the former ON I mine (location 2 Heerlen SON)), mining was done down to a level of 400m, where the cold wells are situated. The extracted mine water is transported to local energy stations via a primary energy grid. In the energy stations, heat exchange takes place between the primary grid and the secondary grid connecting the energy station to the buildings. The secondary energy grid provides low temperature heating (~ 35° – 40° C) and high temperature cooling (16° - 18° C), and one combined return (20° - 23° C).

The two locations, 1 and 2 are connected by a pipeline. Warm water is partly transported from location 1 to 2 and, vice versa, cold water is partly transported from location 2 to 1. Return water of 22 to 23° C is transported to an intermediate well (400m). The temperature levels of the heating and cooling supply are assured in the local energy stations by a polygeneration concept consisting of heat pumps in combination with gas fired boilers and, optionally, a combined heat and power (CHP) plant in combination with local heat storage tanks.

The CHP then provide the electricity to power the heat pumps and also the higher temperature levels (65° – 70° C) for domestic hot water (DHW) and peak heating power demands during extreme conditions. As, with this integral approach, the demand profile of DHW is almost equal to electricity, the CHP can be designed in the most economic and energy efficient way.

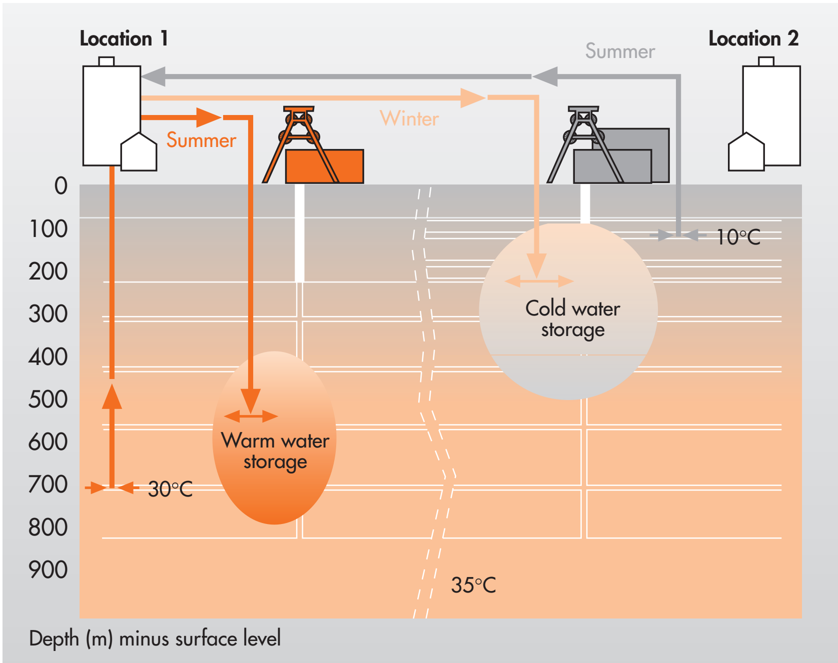


Figure 1: Schematic cross section of the underground conditions of the ON I and ON III mines

The surplus of heat in buildings during hot summers or from industrial processes, which can not used directly in the local energy stations, can be lead back to the mine water volumes for storage. Local sub-energy stations in the buildings provide DHW by heat pumps, small scale CHP or condensing gas boilers wherever necessary to comply with the specific energy profile. The entire system is to be controlled by an Intelligent Energy Management System including the monitoring of the energy uses/flows by the end-users. A scheme of the total concept is given in Figure 2.

Integrated Design Approach
For the development of highly energy efficient buildings, an integral design approach is necessary. An integrated approach must achieve an overall optimisation, taking into account all disciplines and their interactions. The basis is a set of unambiguous, well-defined performance criteria. The design strategy applied is the so-called Trias Energetica3, a three step approach that establishes priorities for realising an optimal sustainable energy solution. In the first step, the energy demand is limited to a minimum level. Step two is to tap renewable energy sources to a maximum share and step three is to use the remaining fossil fuels as efficiently as possible. One of the overall goals is to limit the necessary temperature levels needed for conditioning the buildings.

- Minimum solar and internal gains to limit cooling loads in summer
- Good integration of shading and sun blinds in architectural design
- Application of combined low temperature heating and high temperature cooling emission systems (e.g. thermally activated building components, floor and/or wall heating)

The use of renewable geothermal energy sources does not cover all the energy needs required by the building sector. Sustainable electricity generation can be carried out by cogeneration (such as biomass CHP). This combination can also deliver higher temperatures for DHW. Lower cooling temperatures can become necessary for high cooling loads

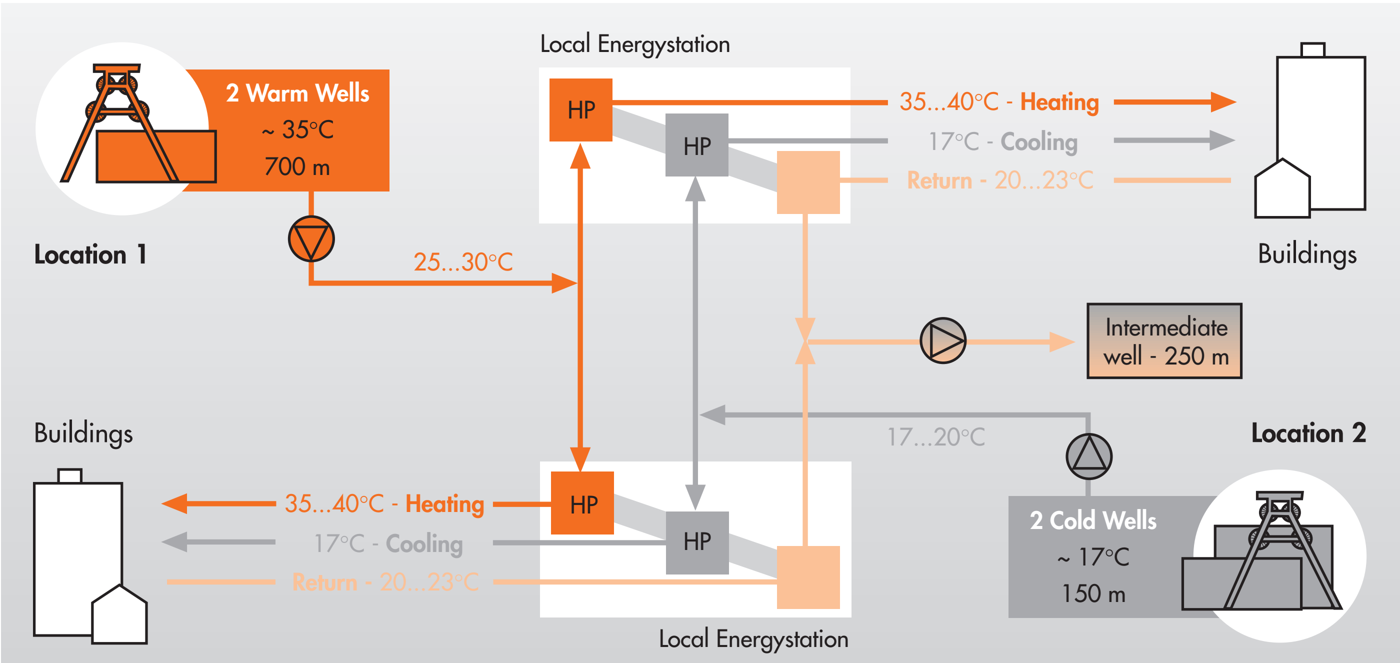


Figure 2: Schematic view of the energy concept in Heerlen, connection of the wells and energy stations

In general, the heating and cooling of buildings can be carried out with very low valued energy and with medium temperatures very close to the required room temperatures. The better the building properties, the closer the temperatures of heat and cold supply can be to the room temperatures. In order to achieve this very good thermal insulation, suitable emission systems are a must. The following points give an overview of the boundary conditions at the building level:

- Very good thermal insulation ($U_{envelope} < 0.25$, $U_{windows} < 1.5$)
- Small ventilation losses by air tight building construction ($n_{50} < 1.0$)
- Mechanical ventilation with heat recovery or-state-of-art demand controlled hybrid ventilation systems

in special building types and processes. For these demands, additional sustainable solutions must be developed.

For the elaboration of the final energy concepts, the following issues must be dealt with:

- total heating and cooling demand, how to control and limit this demand
- the target values for the percentage of renewables in the total energy demand
- the available amount of renewable energy from mine water and other renewable sources
- the most efficient conversion technology for the back-up system

An important tool for the assessment of this process and balancing demand and supply side is the so-called energy profile of a building, expressed in a so-called load-duration curve, based on dynamic calculations (e.g. TRNSYS). This curve is a profile representing the energy demand over one year, including heating and cooling demands. This curve also provides a good indication of the maximal capacities for heating and cooling as well as the balance between heating and cooling demand. Important for balancing the supply and the demand side is the tuning and balancing between the cold and heat sources, in this case, the deep (warm) and shallow (cold) wells. This assessment takes place in relation to the required temperature levels, the yearly extracted volumes and the energy demands of buildings; this in relation to the available water volumes in the reservoirs.

The demonstration locations

Location 1: Heerlerheide Centre:
This site is located in a relatively deep mined area with warm wells (30° - 35° C).

The plans include the following activities for new buildings:

- 33,000 m² (330) dwellings (single family dwellings and residential buildings)
- 3800 m² commercial buildings
- 2500 m² public and cultural buildings
- 11,500 m² health care buildings
- 2200 m² educational buildings

The first new building and construction activities in Heerlerheide Centre started in 2006. The total plan will be carried out between 2006 and 2008. All buildings will be connected to the energy supply (heating and cooling) from mine water. All these buildings are planned in a very compact area which is very favourable for energy distribution because the building location is situated between two potential wells. The two warm wells and the primary net were completed in June 2006, followed by a successful testing period in July. The energy supply includes the building of an energy station and a small scale distribution grid from this station to the buildings. In the energy station, the mine water is brought to the necessary heating and cooling levels by heat pumps. In order to facilitate the process and to guarantee all real estate developers involved in this building plan the delivery of energy to the buildings, the main investor, Housing Corporation Weller, is realising the exploitation of the energy supply, including the building and construction of the energy station and distribution grid.

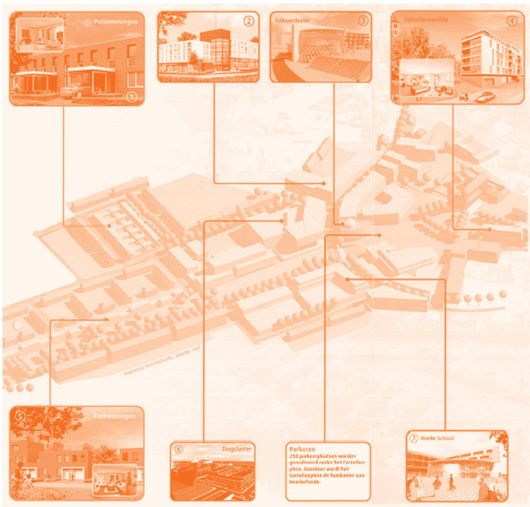


Figure 3: Impression of location 1 Heerlerheide

The total plan will be realised between 2006 and 2008. All buildings will be connected to the energy supply (heating and cooling) from mine water.

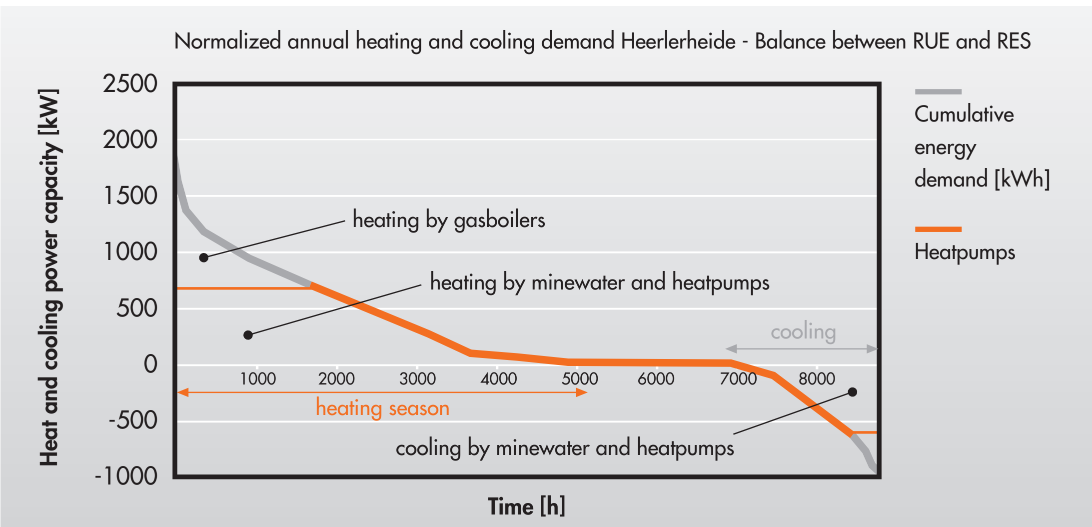


Figure 5: Load-Duration Curve for location 1 Heerlerheide.

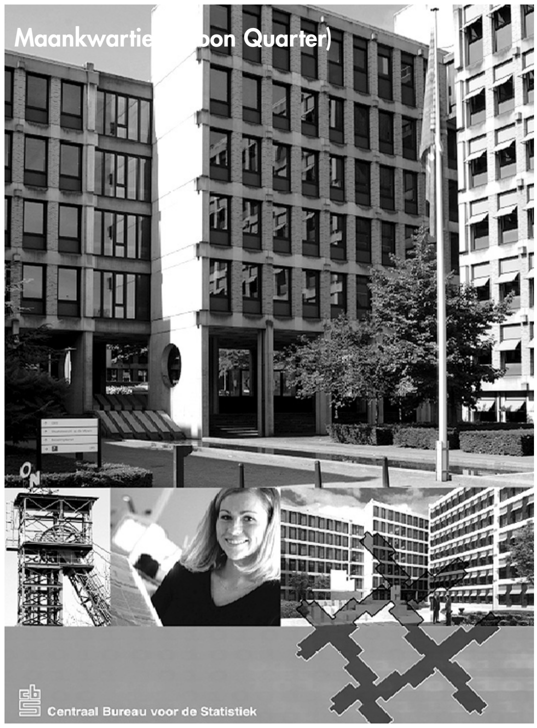
Location 2: SON (Stadspark Oranje, Nassau)
This area is situated on the concessions of the ON I pit. This is a relatively shallow mined area (200 - 400 m) with cold and intermediate wells. Therefore, this area is connected to the warmer wells in the ON III area (Location Heerlerheide). Cold water form the ON I area is transported to the Heerlerheide Centre location. The development of Stadspark Oranje Nassau has a strategic significance for the social and economical rehabilitation of Heerlen. This plan offers an opportunity to improve the image of Heerlen, to develop new economical opportunities and to enhance and stimulate the existing (but poorly functioning) activities of the inner city of Heerlen. This plan will be realized in combination with sustainable mobility and accessibility. The total programme contains the realisation of approximately 100,000 m^2 of new buildings (offices, shops, residences, a school, and a hotel) and the renovation of a large existing office building (43,000 m^2) of the Dutch Central Office of Statistics.

This plan offers an opportunity to improve the image of Heerlen,to develop new economical opportunities and to enhance and stimulate the existing activities of the inner city of Heerlen.

Location 3: Heerlen centre ABP head office
This location concerns the retrofitting of the ABP head office of 40,000 m^2. ABP is the pension fund for employers and employees of the Dutch government and the educational sector. The total building envelope is retrofitted to a better standard than the current Dutch Building Decree requirements for new buildings. The mine water is used for comfort heating and cooling (i.e. low temperature heating and high temperature cooling in all offices). The ABP building will have a direct connection to the mine water wells and will have its own energy station to provide the required temperature levels for the distribution net. The energy station will have additional heat pumps. The emission systems in the offices are climate ceilings. Special glazing will be used to limit solar radiation in summer; this makes it possible to use high temperature cooling (most of the time directly from mine water).

Acknowledgements:
The Minewater project is funded by the European Commission and the Dutch Ministry of Economic Affairs. This funding is gratefully acknowledged.

For further information please visit:
www.minewaterprojekt.info



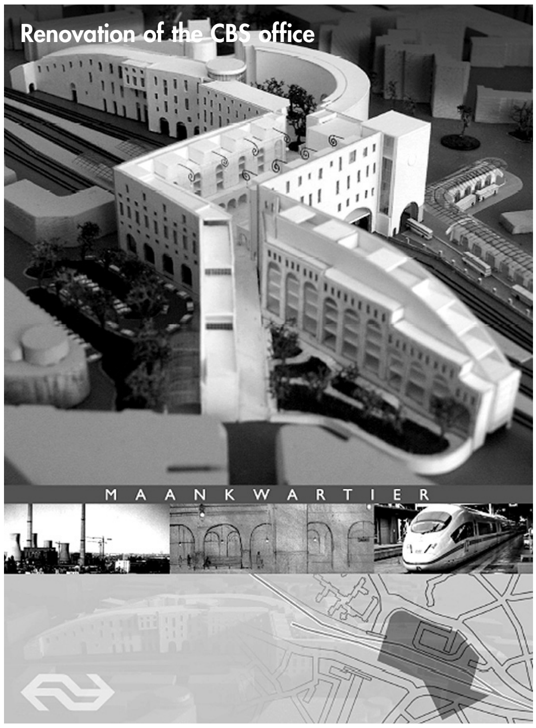


Figure 4: Impressions of location 2 Stadspark Oranje Nassau (SON)

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[2]Municipality Heerlen, PO Box 1, 6400 AA Heerlen, the Netherlands
[3]The approach was introduced in 1996 by Novem in the Netherlands and has been further developed by the Technical University of Delft.

Annex 49

Low Exergy Systems for High-Performance Buildings and Communities

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ECBCS ANNEX 49

Annex 49 is a task-shared international research project initiated within the framework of the International Energy Agency (IEA) programme on Energy Conservation in Buildings and Community Systems (ECBCS).

Annex 49 is a three year project starting in November 2006, following a preparation phase of one year. About 17 research institutes, universities and private companies from 10 countries are currently participating.

For up-to-date date information see:

www.annex49.com

Announcements

- **LowEx workshop** on June 12, 2007 at the CLIMA 2007 Conference in Helsinki (Finland)
- **2nd Expert Meeting** in Yokohama (Japan) October 25 - 26, 2007

International Energy Agency
Energy Conservation in Buildings and Community Systems Programme
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